JUNE • 1956

PETROLEUM REFINER

REFINING | PETROCHEMICALS | NATURAL GASOLINE

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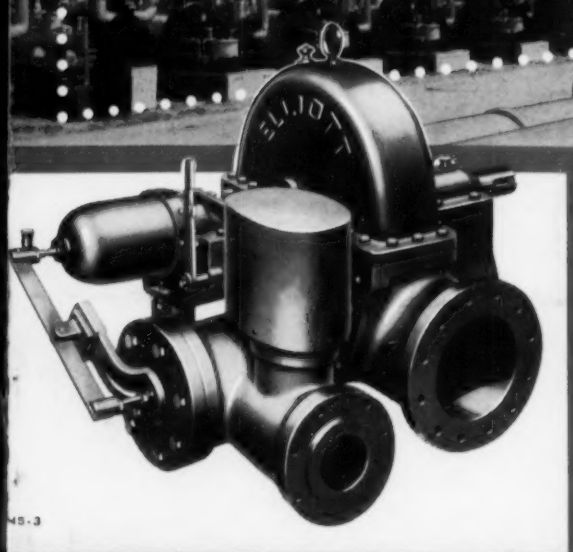
• *Special Report . . .* Research Problems Page 124

• Midget Plants and How They Grew Page 145

Talk about feeling at home!



Distinctively at home, driving a line of oil refinery pumps, are Elliott steam turbines. These modern prime movers are designed to insure low-cost, efficient service — easy maintenance — and long-lasting 24 hour-a-day dependability. They're available with a range of capacities and speeds up to 2000 hp and 7000 rpm. For details contact your Elliott representative, or write to the Elliott Company, Steam Turbine Department, Jeannette, Pa.

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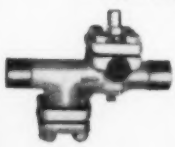

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Volume 35, No. 6 June, 1956

PETROLEUM REFINER
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A Quick Look at This Issue

These handy digests permit checking ✔ those articles you want to read first.

RESEARCH PROBLEMS

☐ **Estimating Research Cost** . . . It's not as hard as you think. Here's what one research director says about estimating. It's based on years of experience with many different research problems. Turn to Page 124.

☐ **When to Use a Pilot Plant** . . . Applied to new processes, pilot plants can be big money savers; but first the questions raised in this article must be answered. The author's twenty-five years experience in this field make him well versed in this problem. Turn to Page 126.

☐ **How to Scale Up Pilot Plant Data** . . . It's a tricky business. Examples in this article will show you the varied techniques involved in scaling up mixing, distillation and reaction rate data. Turn to Page 129.

☐ **What to Avoid in Scale-Up** . . . Here are the traps that you can get into when scaling up pilot plant data. They come from a survey of a large process development organization. For complete details on this informative survey, turn to Page 136.

☐ **Steam Pump Trouble Shooting** . . . Is there a steam pump doctor in the house? If you are having trouble in diagnosing steam pump ailments this should help you. Turn to Page 140.

☐ **Automation Today (Part 3)** . . . A controller tries to nullify the effect of a disturbance to a process. Since there are several types of controllers available, the author describes them and emphasizes their effects with a sample process. For a better understanding of automatic control, turn to Page 141.

→ Now Turn the Page →

A Quick Look at This Issue . . .

☐ **Midget Plants—And How They Grew** . . . Here are three complete descriptions of midget plants—all with a different purpose in mind. Portability was not the goal in the first one. Low volume, rich gas with a long life was the situation in the second. In the third, easy portable construction with conventional processing was the attraction. You'll see an economic case for each one by turning to **Page 145.**

☐ **Nomograph for Combustion Calculations** . . . Here is a valuable tool for keeping close check on combustion performance without using much time. This nomograph gives accurate combustion calculation values from Orsat results. Don't fail to clip this for your working notebook. Turn to **Page 157.**

☐ **Figure NPSH for Proportioning Pumps** . . . To be assured that a proportioning pump will deliver an accurate quantity of fluid, there must be available a sufficient "net positive suction head." For a simple three-step method of determining the NPSH for a pumping installation, turn to **Page 161.**

☐ **Independents Do Big Share of Oil Business** . . . Oil company competition continues strong as ever, i.e., small operators refined 11 percent and produced 38 percent of all U. S. crude last year. For a complete analysis of industry competition, as revealed by a PETROLEUM REFINER-conducted study of oil company annual reports, turn to **Page 170.**

☐ **Recycle Hydrogenated Shale Oil Crude** . . . Gasoline for motor fuel blending or reforming and charge stock for catalytic cracking may be obtained from shale oil crudes by recycle hydrogenation. To see how the sulfur and nitrogen concentrations of shale oil crudes are reduced, turn to **Page 171.**

☐ **Design of Cooler Condensers** . . . Here's a short cut method for a tough and tedious design problem. By introducing a simplifying factor you can eliminate the mass transfer coefficient from the design equation. Don't waste time calculating point-to-point physical constants, use this graphical method, turn to **Page 177.**

☐ **Control the Slurry in Copper Sweetening** . . . and decrease your chemical losses. You will also find that the most successful operation of a sweetening unit is obtained when the water content of the slurry is controlled. You can save time and money for your company by these suggestions on **Page 186.**

☐ **Design Packed Columns** . . . Here is a nomograph that permits diameter, pressure drop and allowable velocity for a packed tower to be determined directly. You are sure to want this for your design calculations file, so turn to **Page 187.**

☐ **New Data for Making Petrochemicals** . . . Are you using excess supplies of natural gas, LPG, natural gasoline, and fuel oil merely for fuel? Why not increase their value 12 times? Use the data in this article to plan your petrochemical venture. Turn to **Page 189.**

☐ **Check Effluent With Bioassay** . . . A pollution abatement program without the inclusion of bioassay methods can be expensive and inconclusive. This article discusses how bioassay can help determine the harmfulness of wastes fast and inexpensively. Study your program for stream improvement and compare these methods with your test procedure. Turn to **Page 197.**

☐ **A Refiner's Reaction to RP-500** . . . Are you buying explosion-proof electrical equipment for non-hazardous areas? Here is one refinery's experience with the new API standard on classifying hazardous areas. Turn to **Page 202.**

☐ **Baytown Refinery Virtually Rebuilt** . . . For the story of ten years of construction; how it changed Humble's refining operation, and gave the Baytown refinery the character of a chemical plant, turn to **Page 122.**

☐ **Are Your Employe Communications Effective?** . . . No business can operate in a communication vacuum—particularly the dynamic oil industry. For a comprehensive analysis of the vital role communications plays in employe relations, plus a detailed discussion of good and bad communications approaches, turn to **Page 228.**

☐ **Are You a Good Interviewer?** . . . Every interviewer feels he is at least fairly good at his job, yet when two people interview the same person they rarely reach the same conclusion. The need for better interviewing methods is obvious. For a critical analysis of modern interviewing methods, plus many excellent suggestions for improvement, turn to **Page 232.**

☐ **Five Steps to Safety** . . . Many a well-planned safety program has floundered because of too many generalities. Here are five ways to insert the all-important "you" factor into your program through application of *specific* planning beamed at the *individual* employe. Turn to **Page 238.**

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WORLD OIL (formerly The Oil Weekly) and The COMPOSITE CATALOG for the drilling-producing industry

PIPE LINE INDUSTRY and The PIPE LINE COMPOSITE CATALOG (first edition to be issued in July, 1957) for the oil and gas pipe line industry.

Petroleum Refiner is indexed by Industrial Arts Index, Chemical Abstracts and by Engineering Index, Inc. Microfilm copies available through University Microfilms, An Arbor, Michigan.

Story About a Story

REMEMBER the article on recruiting college graduates for oil industry service in the March PETROLEUM REFINER? It was a sample of the constructive articles we like to work up. And apparently colleges and oil companies like it, too. More than 50 oil companies and colleges have asked for nearly 400 reprints—and requests are still coming in. Here are sample comments:

". . . We have found it very helpful . . . please send 12 additional copies."—**E. A. Lewis, Supervisor of Employe Relations, Gulf Oil Corporation.**

". . . We would appreciate receiving 30 additional copies of this reprint . . ."—**A. J. Alstrom, Division Manager of Personnel, Standard Oil Company of California.**

". . . Your article, 'Employing the College Graduate,' is the best summary I have seen to date on the recruiting situation. I would appreciate copies of the reprint sent to the following . . ."—**Lewis M. Knebel, Placement Director, University of Maryland.**

". . . It has been read with a good deal of interest. So that I may distribute this article to several of our departments, I would appreciate your forwarding to me 15 additional copies."—**D. A. Sedgwick, Assistant to Vice President, Industrial and Public Relations Department, The Texas Company.**

". . . We enjoyed reading your recent article . . . if possible, we would appreciate your sending us 15 copies for distribution to our Division Employe Relations Advisors."—**C. E. Duran, Supervisor-Employment, The Carter Oil Company.**

". . . We deeply appreciate the service your organization has rendered to us all with reference to wise placement procedures."—**W. R. White, President, Baylor University.**

". . . You are to be congratulated for providing this information to both colleges such as ours and oil companies interviewing on our campus."—**Phillip C. Worden, Head, Placement Bureau, New Mexico Institute of Mining and Technology.**

". . . I would like to request that 20 additional copies be forwarded to my attention if they are available. It is our intention to mail reprints of this article to our college recruiters throughout the country."—**L. W. Armon, Employment Supervisor, United States Rubber Company.**

Right On the Nose!

WHEN OUR editors return from trips it is their practice to make written reports of their observations, findings, recommendations, etc. It was from such a recent report by Tom Ponder, our petrochemicals man, that we gleaned a gem that caused a peculiarly satisfying feeling. Here 'tis:

"At the ——— plant, the general manager said he was a regular reader of THE REFINER. He likes the general articles on equipment that apply to both refining and petrochemical plants. He said almost as soon as they start to plan a plant change or modernization project an article appears in THE REFINER dealing with the very subject on which they are working."

That's what is known as hitting 'em on the nose!

Inco high temperature research note:

Nitriding

...and its effects on several heat-resisting alloys

As a constituent of many hot atmospheres that employ air for combustion, nitrogen in molecular form is usually considered substantially inert to a large number of metals and alloys.

However, in atomic state—for example, as a transient dissociation product of ammonia – nitrogen may react with surfaces of certain metals and distinctly alter their properties. Whether this may be desirable or not, depends on extent and nature of the reaction.

The Problems

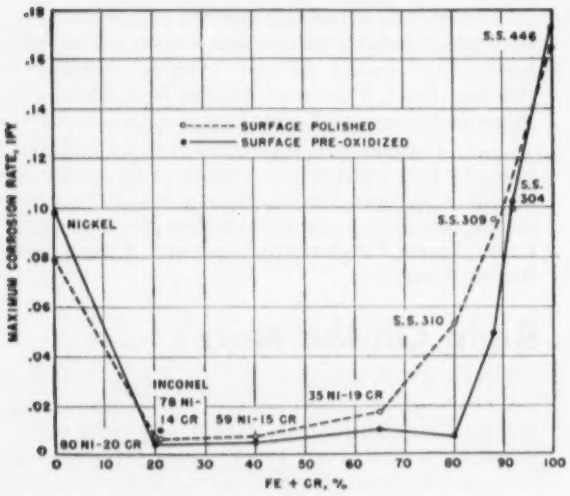
Industry heats steels to be intentionally nitrided, in a freshly dissociated ammonia atmosphere to attain the surface hardening that accompanies formation of nitride phases. But the problem is, to avoid nitriding the furnace chamber, dissociator and other accessories . . . a costly and useless consumption of gas. Another problem exists in chemical plants, where equipment handling hot ammonia must resist the absorption of nitrogen. Here nitriding is a form of high temperature corrosion requiring selection of the most resistant alloys for its prevention.

A Postulate

Field experience had shown that alloys high in nickel resist corrosion and embrittlement by nitrogenous atmospheres. However, to evaluate lower nickel alloys

CORROSION OF NI-CR-FE ALLOYS BY ANHYDROUS AMMONIA AT 500°C

BASED ON 1540 HOURS EXPOSURE



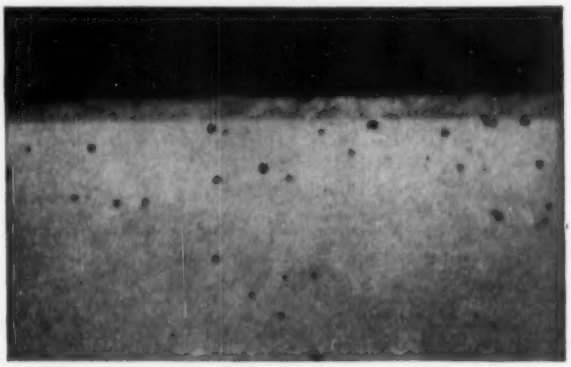
in this type of service, a series of commercial compositions was exposed in a plant ammonia line and the corrosion behavior thereafter compared.

Examination

After 1540 hours' exposure at 500°C, stainless steels having initially a bright surface suffered heavy corrosion that was quantitatively measured by examination of the specimen cross section under the microscope. These measurements were calculated in terms of "inches penetration per year" and the variation in extent of attack with alloy composition is shown in the graph.

When the nickel content is high, as in 80 Ni/20 Cr, 78 Ni/14 Cr (Inconel* nickel-chromium alloy), or 59 Ni/15 Cr, the nitride phases which form are dense and adherent and the corrosion resistance is correspondingly good. Alloys that contain more iron develop porous surface layers and the rate of attack is high. Significantly, apparently some chromium is required to provide corrosion resistance, since under these conditions of exposure, pure nickel is inferior.

An interesting observation from this test is that the stainless steels which were initially heat-treated to form an oxide film were more resistant than specimens with a bright surface.



Material Magnification dark zone nitride rich corrosion layer.

Result of Investigation

Quantitative data obtained from this test in general support past experience that the high nickel compositions are inherently suited for service under nitriding conditions.

Inco has investigated hundreds of metals and alloys under high temperature operating conditions. If you have a metal problem involving high temperature performance in corrosive media, let us help you. Send for our High Temperature Work Sheet . . . a form that makes it easy for you to outline your problem to us. Use the coupon now.

*Registered Trademark

The International Nickel Company, Inc.
67 Wall Street, New York 5, N. Y.

Please send me the High Temperature Work Sheet so that I may outline my problem to you.

Name _____

Title _____

Company _____

Address _____

City _____ **State** _____

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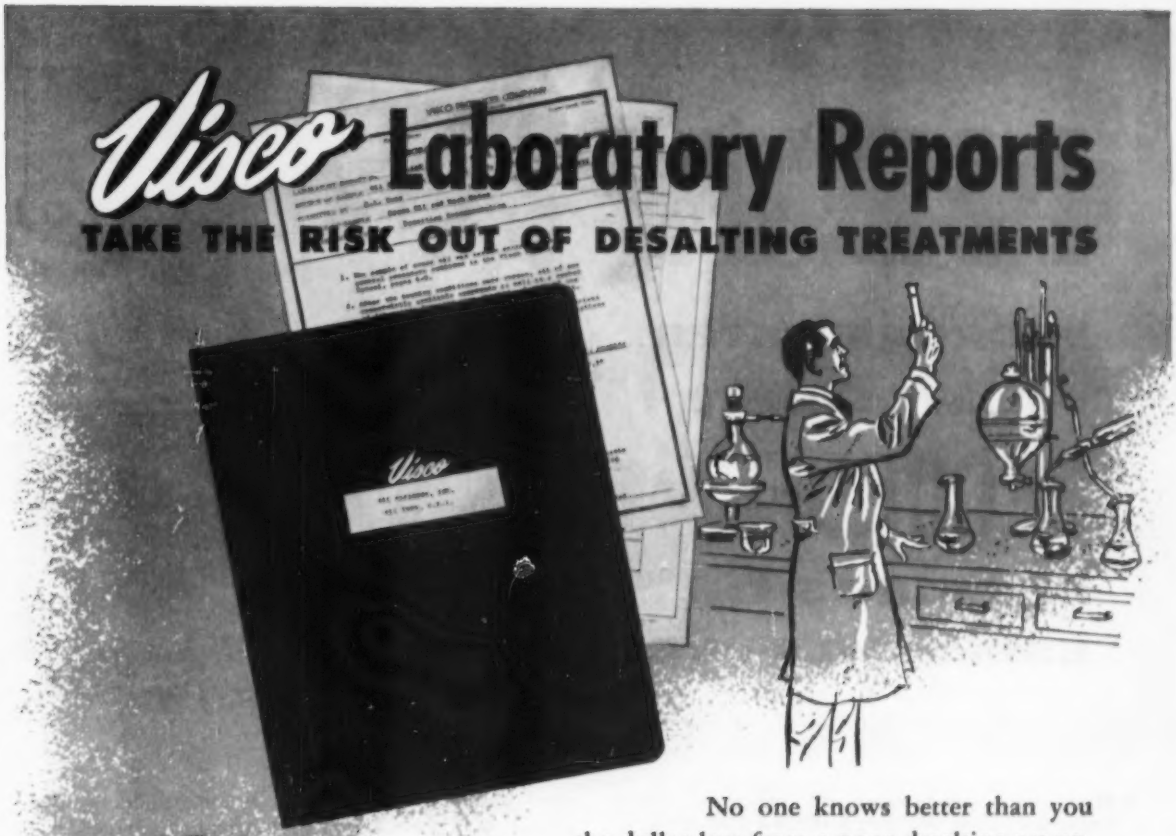
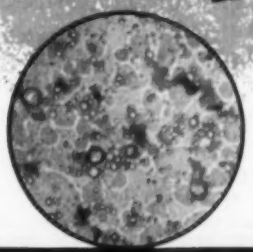
Visco Laboratory Reports

TAKE THE RISK OUT OF DESALTING TREATMENTS



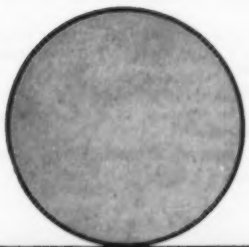
No one knows better than you the dollar loss from a poor desalting set-up.

And you know, too, there's no such thing as a blanket cure-all. But a Visco Laboratory Report *does* point the way to the results you want—from every type of crude—at no added cost to you.



Photomicrograph—
Emulsified refinery crude

In a typical case, 20 or more separate desalting compounds and laboratory formulas may be checked and all contributing factors will be considered before the final desalting recommendation is made.



Photomicrograph—Emulsified refinery crude after Visco desalting

If you would like our desalting recommendation for your crude, send Visco a five-gallon can of the crude and one gallon of the water used in your refinery desalting. Or better yet, check with your Visco representative, and he will arrange for these services.

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Visco® CONSISTENTLY EFFICIENT OIL INDUSTRY CHEMICALS

For more data on advertised products, use Readers' Service Cards, last page.

NEW

MICROAMMETER
MILLIVOLTMETER
RECORDER
PERFORMS 6
ESSENTIAL FUNCTIONS

★ **Measures low-level dc signals with calibration accuracy within 0.5%, and sensitivity within 0.2% of span.**

★ **Records on 3" continuous strip chart or IBM-type card chart, with linear coordinates.**

★ **Positions recording pen with force many thousand times greater than usual direct-deflection electrical movements.**

★ **Operates on force-balance principle compensating for ambient conditions, changes in power supply and components.**

★ **Gives high-speed recording — up to 0.05 seconds for 63% of fullscale changes.**

★ **Provides span and zero adjustments for ease of calibration and zero suppression in the field, without special equipment.**

The new 'American-Microsen' Series 130 Recorder is a highly sensitive microammeter or millivoltmeter that gives positive, accurate electrical measurement and rugged, maintenance-free service. Yet the unit costs less than other recorders for the same purpose.

Heart of the Series 130 Recorder is the "Microsen" balance that converts low-level dc input signals into powerful output current to drive the recording pen. Pen position is fed back to the input. Consequently, the recording unit is force-balanced in precise relationship with the input signal. Power is ample to operate alarm contacts, which are available.

SPECIFICATIONS

POWER SUPPLY: 115 volts, 60 cycles. **POWER REQUIREMENT:** 9 watts

INPUT RANGES: Voltage – 0-20 millivolts to 0-100 volts dc. **Current** – 0-200 microamperes to 0-100 milliamperes dc. **Input Sensitivity** – 6700 ohms per volt.

ACCURACY: ± 0.5% of span. **SENSITIVITY:** ± 0.2% of span. **REPEATABILITY:** ± 0.25% of span.

EFFECT OF SUPPLY VOLTAGE: Less than 0.5% error 90-130 volts.

EFFECT OF AMBIENT TEMPERATURE: Less than 0.5% error 50° to 100° F., and less than 1% to 130° F.

RESPONSE TIME: Fast Speed – 0.2 seconds standard for 63% of fullscale input change; up to 0.05 seconds for 63% on special order. **Slow Speed** – approximately 4 times fast speed setting.

SHOCK RESISTANCE: Withstands shock up to 30 times gravity.

CHART SPEEDS: Strip Chart – 1" per hr., standard; 3" or 6" per hr. available. **Card Chart** – 1 rotation per day, standard.

SPAN ADJUSTMENT: ± 10% of span. **ZERO ADJUSTMENT:** ± 100% of span.

PRICE: $250.00 consumer net for standard models.

Write for Bulletin MG10

MANNING, MAXWELL & MOORE, INC.

MAXWELL MANNING MOORE INC. TRADE MARK

INDUSTRIAL CONTROLS DIVISION, STRATFORD, CONNECTICUT

MAKERS OF 'AMERICAN-MICROSEN' ELECTRONIC TRANSMITTERS, INDICATORS, RECORDERS, CONTROLLERS, ELECTRO-PNEUMATIC VALVE POSITIONERS AND ELECTRO-HYDRAULIC CONTROL VALVE OPERATORS.

For more data on advertised products, use Readers' Service Cards, last page.

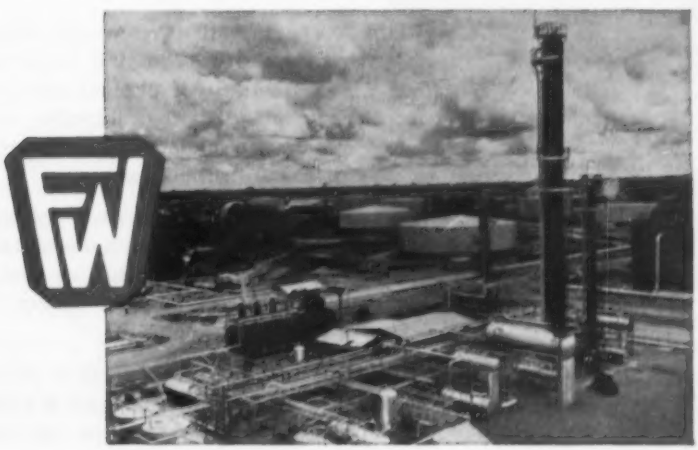
alkylation

...for "MOTOR" OCTANE

The persistent trend to higher compression ratios in automotive engines is focusing attention on alkylation as an important process means for increasing a refinery's Octane potential.

Foster Wheeler is currently designing and constructing an alkylation unit for a midwestern refiner which will produce 3800 bbl/day of motor alkylate. This unit features "effluent refrigeration," the most significant advance in alkylation technology in 15 years.

The unit shown in the photograph, recently completed for a South American refiner, is but one of the 17 alkylation units designed and constructed by Foster Wheeler. This cumulative experience is available to refiners everywhere — for evaluating the economics of the process and undertaking full responsibility for plant design and construction. For complete information, write to *Foster Wheeler Corporation, 165 Broadway, New York 6, N.Y.*



FOSTER WHEELER

NEW YORK • LONDON • PARIS • ST. CATHARINES, ONT.

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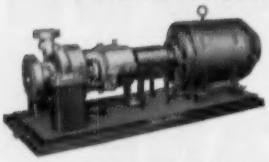
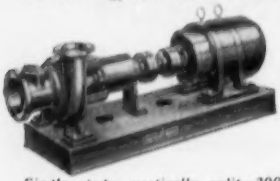
AN I-R PUMP FOR EVERY REFINERY APPLICATION

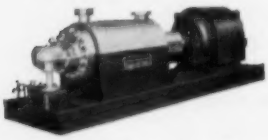


Single stage, vertically split—20-3200 gpm, heads to 600 ft.

Single and two stage, vertically split—20-3500 gpm, heads to 1100 ft.



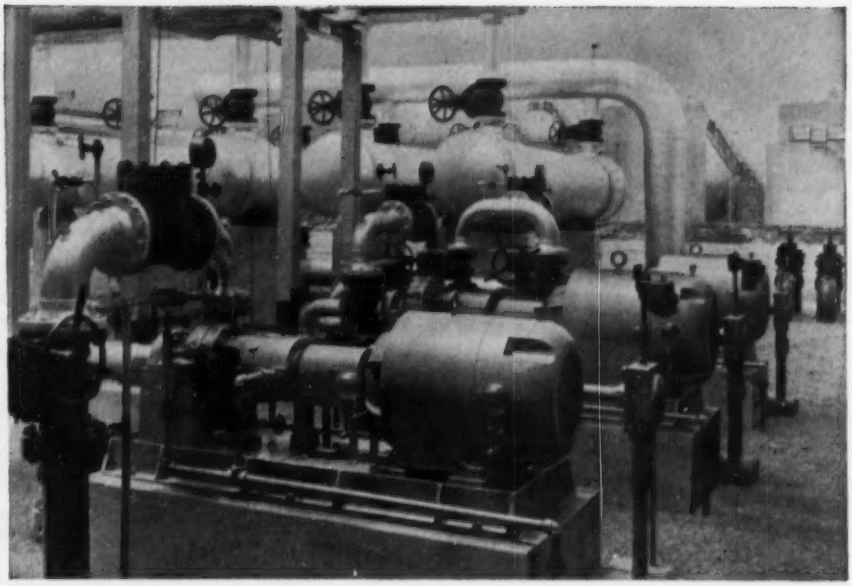
Single stage, vertically split—200-7000 gpm, heads to 225 ft.



Multi-stage horizontal diffusor type—450-3000 gpm, heads to 6000 ft.

Multi-stage vertical diffusor type—20-400 gpm, heads to 4800 ft.

Single or multi-stage vertical turbine pumps—60-35,000 gpm, heads to 150 ft. per stage.



How IR refinements in pump design mean long range savings in REFINERY SERVICE

What determines your choice when selecting a pump for a given job?

You want the pump that gives you the *most* for the money—the most *dependable* service, highest *sustained* efficiency, and lowest year-after-year maintenance cost. And all these result from refinements in pump design and manufacture.

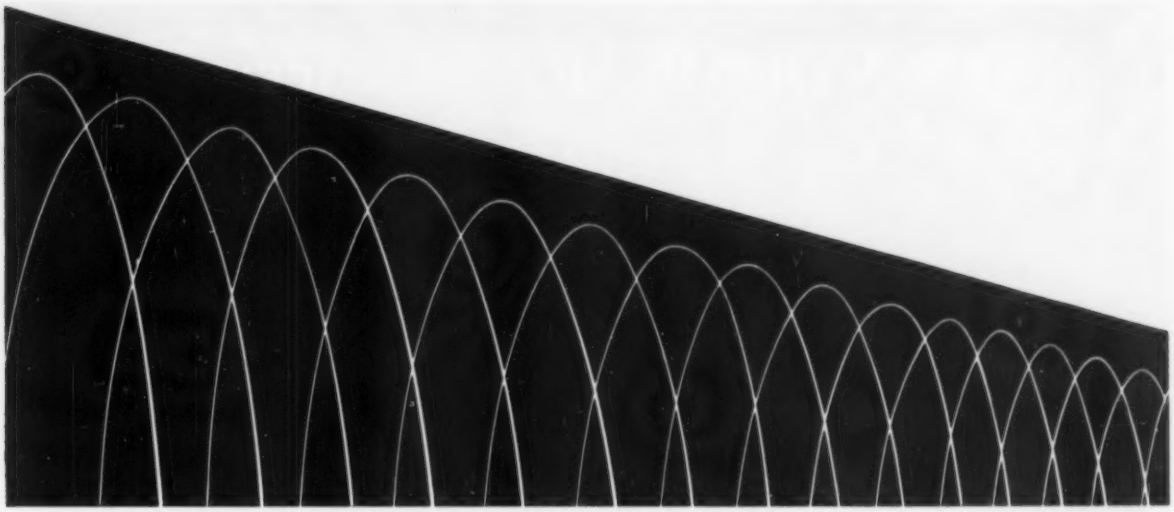
In all I-R process pumps, these refinements have been carried to the fullest extent. Unsurpassed metallurgical facilities assure proper material selection and heat treatment of all pump parts to meet actual service conditions to best advantage. Casings, impellers, wearing rings, shaft sleeves are built of materials formulated to minimize the effects of corrosion, erosion, expansion and thermal shock.

Running clearances of all moving parts are proportioned not just for a high initial efficiency, but for maximum sustained efficiency year after year. Easier accessibility for inspection or servicing cuts down-time. Extensive interchangeability of parts throughout the entire I-R line simplifies stocking of replacement parts.

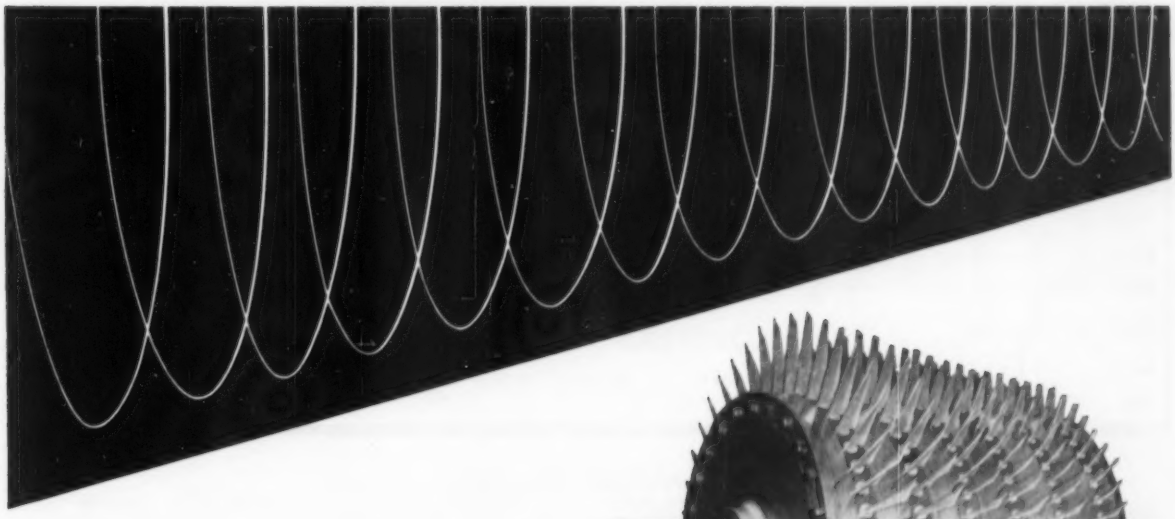
Your Ingersoll-Rand representative will be glad to give you the complete story on the extra-value features of any I-R pump. His specialized design and application experience can save you time and effort on any job.

Ingersoll-Rand

10-312 **11 Broadway, New York 4, N. Y.**



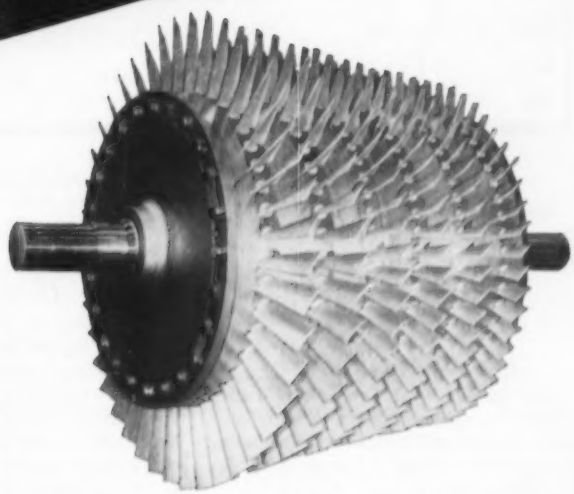
Carrier Axial Flow Compressors set record of 40 million operating hours



From Carrier, the people who have built more multi-stage compressors than any other company in the world, now come new records for axial flow compressors. The hundreds of Carrier Axial Compressors in use have given dependable service for a cumulative total of 40 million operating hours!

Carrier Axial Flow Compressors can meet your process needs where exceptionally large volume air or gas compression is required. Frame sizes are rated up to a quarter-million cubic feet per minute when operating on air.

If you would like a copy of our folder on axial flow compressors, or further information about how to meet special large volume flow requirements, call your nearest Carrier office. Or write Carrier Corporation, Syracuse, New York.



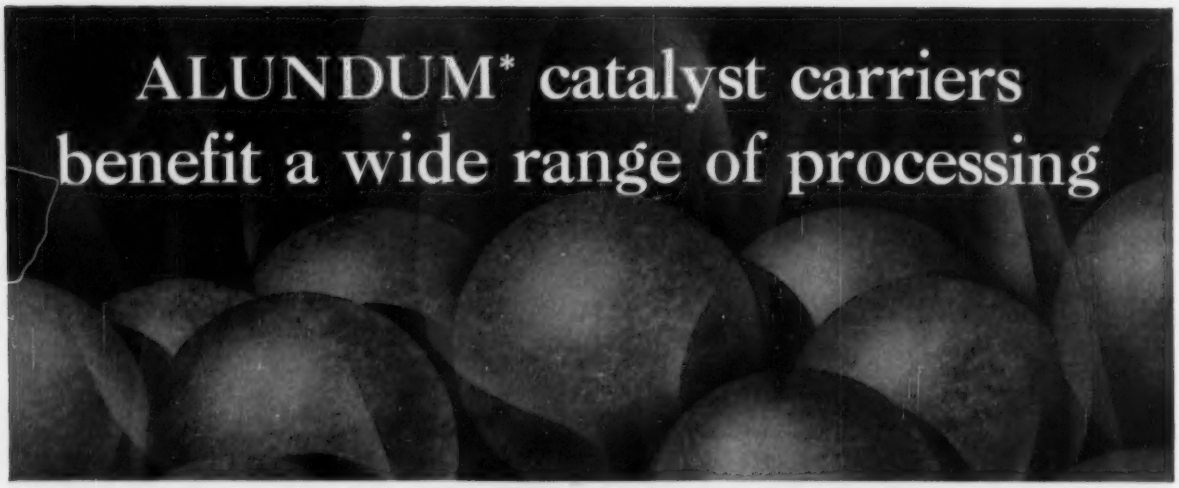
This massive rotor is the heart of the Carrier Axial Flow Compressor.

Carrier

COMPRESSORS FOR INDUSTRY
REFRIGERATING EQUIPMENT

For more data on advertised products, use Readers' Service Cards, last page.

ALUNDUM* catalyst carriers benefit a wide range of processing



Norton ALUNDUM (fused alumina) catalyst carriers are characterized by excellent mechanical, thermal and chemical stability. They have high resistance to abrasion and erosion, and their low density is useful for packing and filling applications. Catalytically, they are crystalline in nature and are produced in two surface area types: low and intermediate. Intermediate surface area carriers are subdivided into types A, B, C, with varying characteristics.

TYPICAL CHEMICAL ANALYSES (%'s)		
	LOW SURFACE AREA	INTERMEDIATE SURFACE AREA
Al_2O_3	89.4–76.6	77.0
SiO_2	9.3–16.8	21.2
Fe_2O_3	0.5 – 1.3	0.2
MgO	0.1 – 0.6	0.4
CaO	0.1 – 0.8	
Na_2O	0.3 – 0.4	0.5
K_2O	0.1 – 1.0	0.2
TiO_2	0.2 – 2.5	0.5

PHYSICAL PROPERTIES						
	Porosity	Water Absorption	Bulk Density	Vol. Bulk Density	Crystal Structure	Surface Area
Low Surface Area	40-50%	20-25%	1.90-2.10 gr/cc	65-80 lbs/ft³	Alpha Alumina	Less than 1m²/gram
Intermediate Surface Area Type A	50-55%	28-30%	1.65-1.70 gr/cc	58 lbs/ft³ (app)	Alpha, Gamma Alumina-chiefly Gamma	60-70m²/gram
Type B	50-55%	28-30%	1.65-1.70 gr/cc	60 lbs/ft³ (app)	Quartz, Alpha, Kappa, Delta Alumina-chiefly Quartz	20-30m²/gram
Type C	50-55%	28-30%	1.65-1.70 gr/cc	62 lbs/ft³ (app)	Alpha Alumina and Mullite	5-10m²/gram

Shapes and Sizes

Spheres: (Low surface area) 3/16"-1" diam.; (Intermediate surface area) 1/4"-1/2" diam. *Pellets:* (All carriers) 1/8" x 1/8" — 1/2" x 1/2". *Rings:* (All carriers) 1/8" x 1/4" x 3/8" O.D. — 1" x 1 1/2" x 1 1/2" O.D.

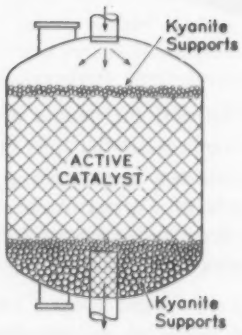
Typical Applications

Low Surface Area Carriers: phthalic anhydride, maleic anhydride, ethylene oxide, protective atmospheres, synthetic gas generation, grates or suspending beds for active catalysts.

Intermediate Surface Area Carriers: catalytic reforming, dehydrogenation, dehydration, sulfuric acid manufacture, nitric acid manufacture, dessicants.

In Suspending Beds For Active Catalysts

In addition to the carriers described here, Norton produces catalyst supports for use in fixed bed convertors where it is necessary to suspend active catalysts at a given level. Made of dense, rugged, chemically inert Kyanite material, these supports have great resistance to breakdown and have no chemically reactive effect on the processing.



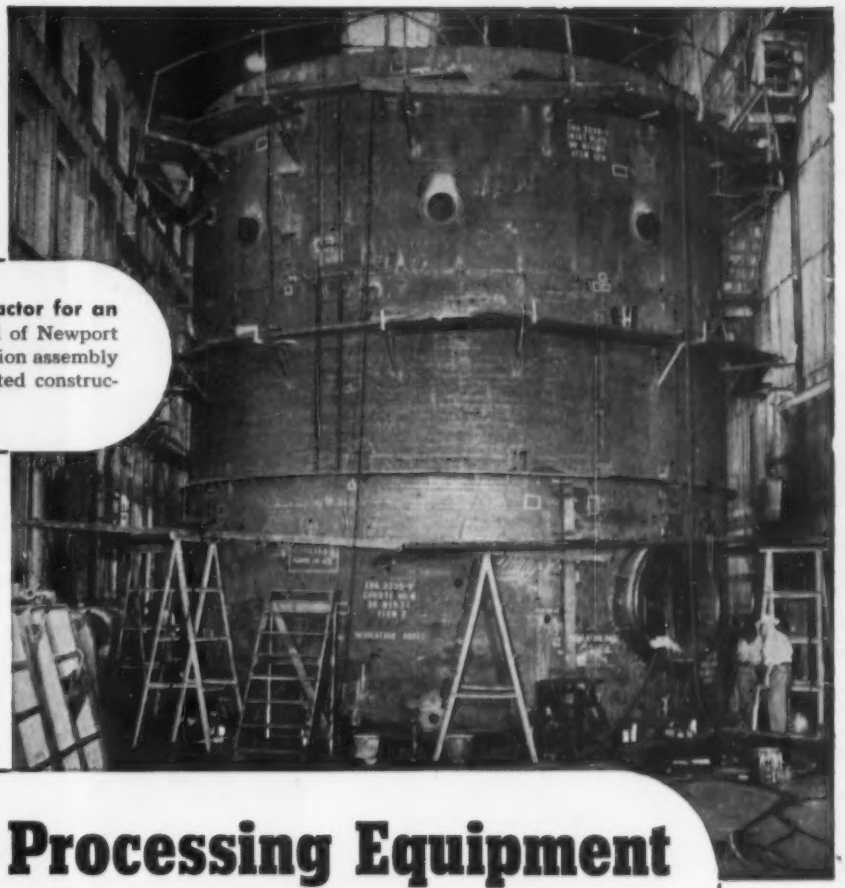
Get More Facts

on how ALUNDUM catalyst carriers and Kyanite supports can improve and economize your processing. Call in your Norton Refractories Engineer or write, mentioning your requirements, to NORTON COMPANY, 465 New Bond St., Worcester 6, Mass. *Canadian Representative:* A. P. Green Fire Brick Co., Ltd., Toronto 5, Ontario.

NORTON
REFRACTORIES
Engineered... Rx ...Prescribed

Making better products... to make your products better

For more data on advertised products, use Readers' Service Cards, last page.



Course number four of a reactor for an overseas oil refinery. Typical of Newport News plant methods, the precision assembly of this unit in the shop expedited construction of the reactor in the field.

Petroleum Processing Equipment

...Built by Specialists in Metal Fabrication

Careful attention to detail characterizes the work of Newport News craftsmen...

They've fabricated millions of tons of steel including corrosion-resistant alloy, clad and other special steels for many diverse industries.

Newport News handles the job exactly as you want it done, for maximum results per dollar invested.

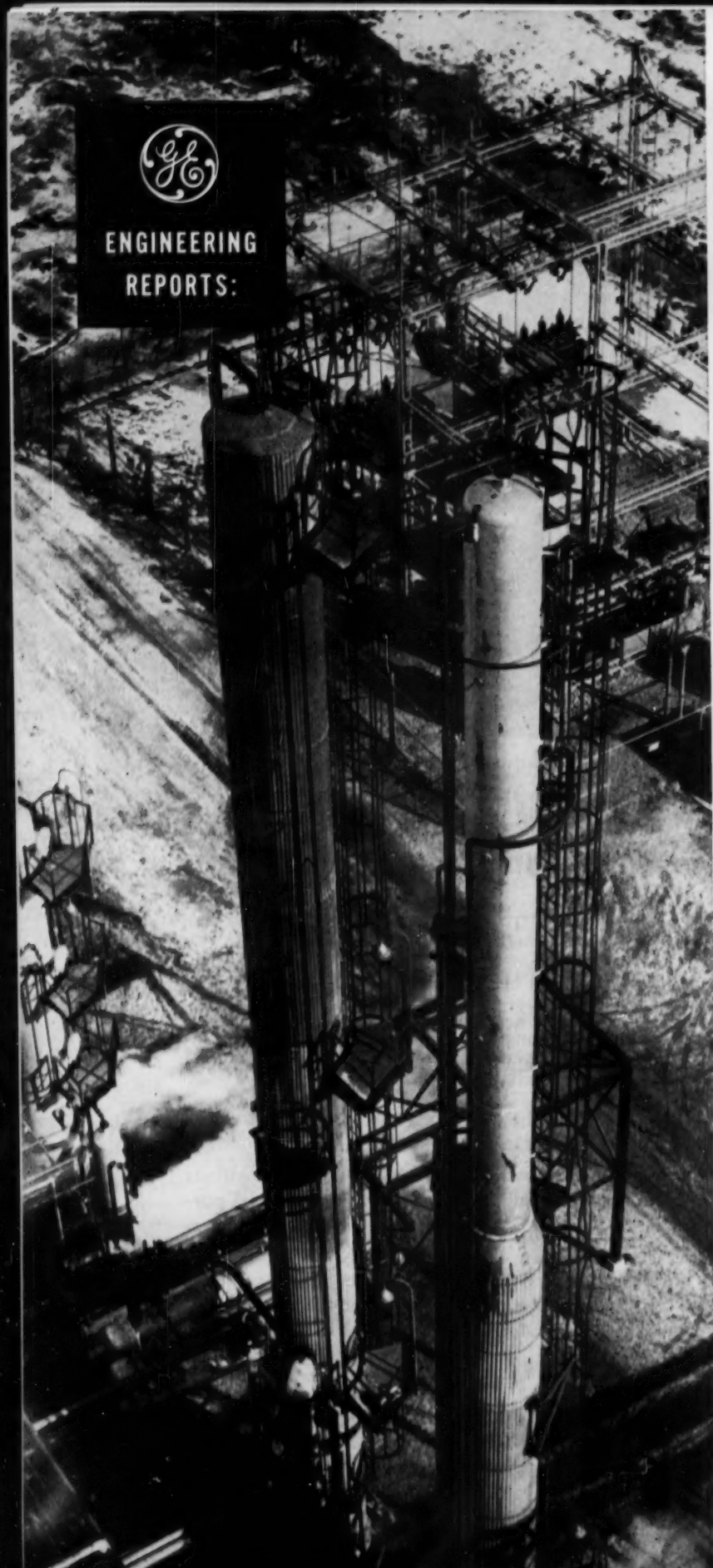
Specialized production techniques, advanced plant methods and a complete range of facilities along with many special purpose machines contribute to the excellence of Newport News fabrication.

Let us bid on equipment for your present or future projects. Learn how Newport News can help you...send for our booklet entitled "Facilities and Products." It's yours for the asking.

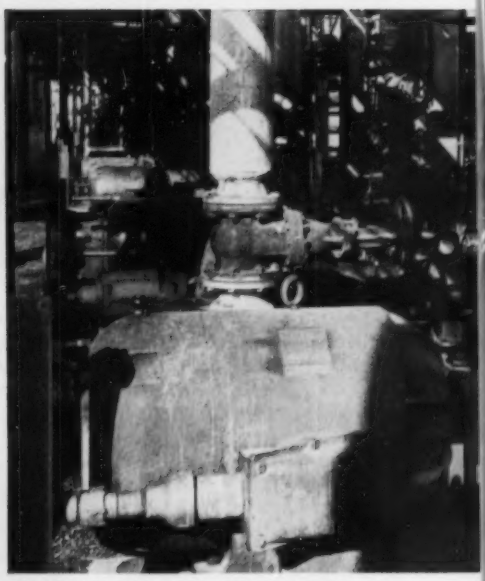
Newport News Shipbuilding and Dry Dock Company

Newport News, Virginia

For more data on advertised products, use Readers' Service Cards, last page.

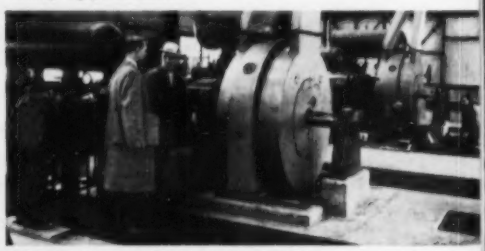


ENGINEERING
REPORTS:

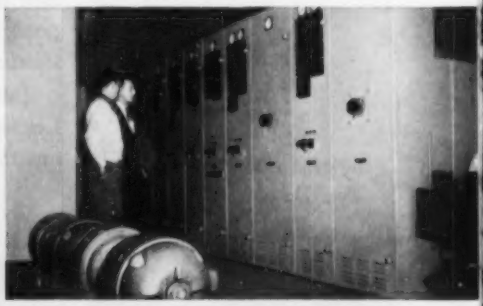


EXPLOSION-PROOF, totally enclosed, 60-hp induction motor is one of 14 G-E

RUGGED CONSTRUCTION of G-E explosion-proof, totally enclosed, Tri-Clad* '55' motors make them ideal for outdoor refinery applications.

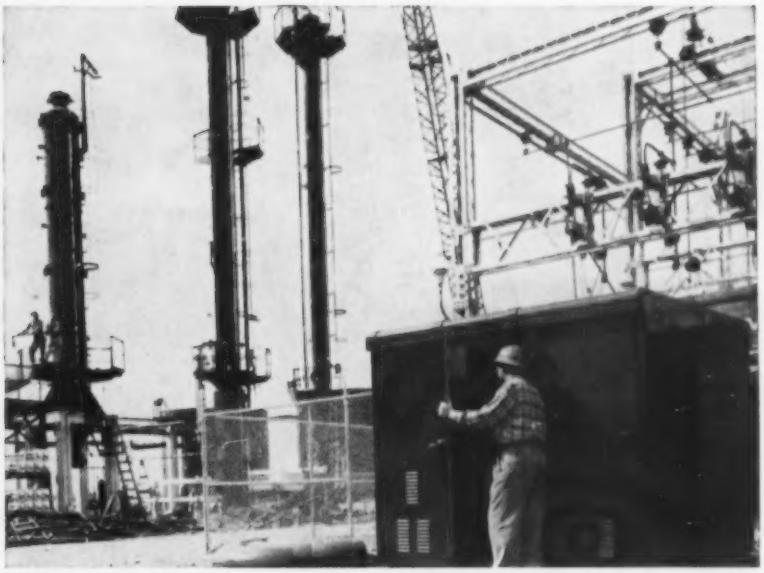


SPECIALLY VENTILATED against process fumes, two G-E 300-hp synchronous motors drive compressors in the new refining unit.



COMPACT AND EASILY INSTALLED, G-E metal-clad switchgear, rated 2400 v, controls synchronous drives for pumps and compressors. *Reg. trade name of the General Electric Co.

motors located on the refinery pipeway. Motors require no protective housing.



METAL-CLAD STATION SWITCHGEAR is located outside fenced-in area containing transformers and high-tension circuit breakers; is enclosed against dust and weather.

Bay Refining boosts capacity by 6000 B. P. D. with help of General Electric distribution system

BAY REFINING CORPORATION describes their new catalytic cracking and catalytic polymerization unit, on stream early in 1955, as "Making use of the latest engineering and refinery concepts known to man." The Southwestern Engineering Company of Los Angeles, Engineers and Constructors, was able to complete this modern unit right on schedule—and bring Bay Refining's total capacity to over 10,500 b.p.d. To help meet their schedule, General Electric shipped the electrical equipment according to Southwestern's prearranged timetable, to arrive at the building site when needed.

ELECTRICAL SYSTEMS are fast becoming the standard for refinery prime drive and process control requirements. General Electric offers a complete line of electrical equipment, in a variety of sizes and protective enclosures, to meet refinery needs for greater continuity of service and lower maintenance requirements in a highly corrosive atmosphere.

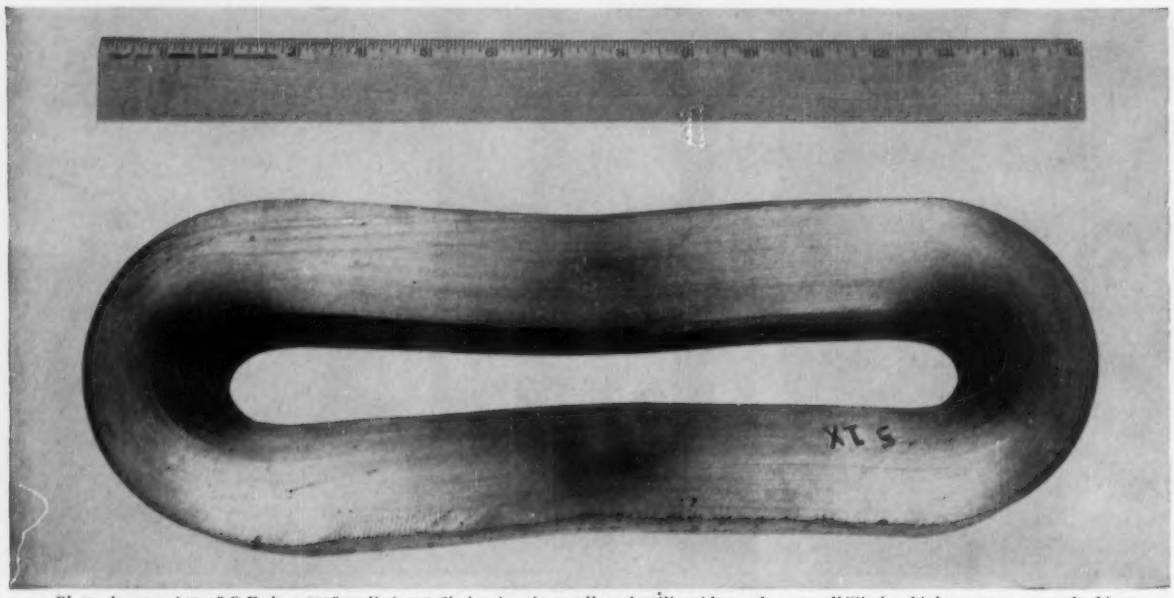
IN ADDITION, to further help you meet your production requirements, G.E. offers a complete line of engineering services performed by men who know your industry and its electrical problems. They are available to you and your consultants to help design, schedule, supervise installation, and start up an engineered electrical system planned to meet your needs.

- **Project Co-ordination**
- **Application Engineering**
- **Product Development**
- **Analytical Engineering**
- **Installation and Service Engineering**
- **Maintenance Service**

Your G-E Apparatus Sales Representative will tell you more about G-E electrical equipment and Engineering Services for the petroleum industry. Contact him at your nearest Apparatus Sales Office and write for bulletin GED-2244, "Engineering Services," to General Electric Co., Section 681-11, Schenectady, N. Y.

Engineered Electrical Systems for the Petroleum Industry

GENERAL ELECTRIC



Flattening test of 10½" O.D. by 1.580" wall of 18-8 Cb showing the excellent ductility of large, heavy-wall Timken high temperature steel tubing.

To get the best possible tube life per dollar: *Ask the experts!*

This month's report is on:

SICROMO 7

Suggested as a substitute for steels of the 5.0 per cent chromium type for applications which require increased resistance to corrosion by hot petroleum products.

ONE OF 24 TIMKEN HIGH TEMPERATURE STEELS

Carbon	Sicromo 2	Sicromo 5S	18-8 Ti
Carbon-Mo.	Sicromo 2½	Sicromo 5MS	16-13-3
DM-2	2½% Cr.-1% Mo.	Sicromo 7	25-20*
Silmo	Sicromo 3	Sicromo 9M	25-12*
DM	4-6% Cr.-Mo.	18-8 Stainless	35-15**
2% Cr.-Mo.	4-6% Cr.-Mo.-Ti.	18-8 Cb	16-25-6**

** Available as seamless tubing on an experimental basis only.*
***Not available as seamless tubing.*

SEVERAL analyses of high-temperature steels may solve your temperature, pressure, corrosion, and oxidation problems. But to get the best life/cost ratio —the best possible tube life per dollar—there's actually only one analysis that's best for you.

To get it, ask the experts—metallurgists of The Timken Roller Bearing Company. They're recognized authorities on high-temperature steels—with more than 25 years of high-temperature steel research and experience behind them. From the 24 different analyses at their disposal, let them help you choose the *one* tube steel analysis that's best for your particular job. Whatever one you choose, you can be assured of uniform quality. That's because the Timken Company rigidly controls quality from melt shop through final tube inspection. The Timken Roller Bearing Company, Steel and Tube Division, Canton 6, Ohio. Cable address: "TIMROSCO".

YEARS AHEAD—THROUGH EXPERIENCE AND RESEARCH

SPECIALISTS IN FINE ALLOY STEELS, GRAPHITIC TOOL STEELS AND SEAMLESS TUBING

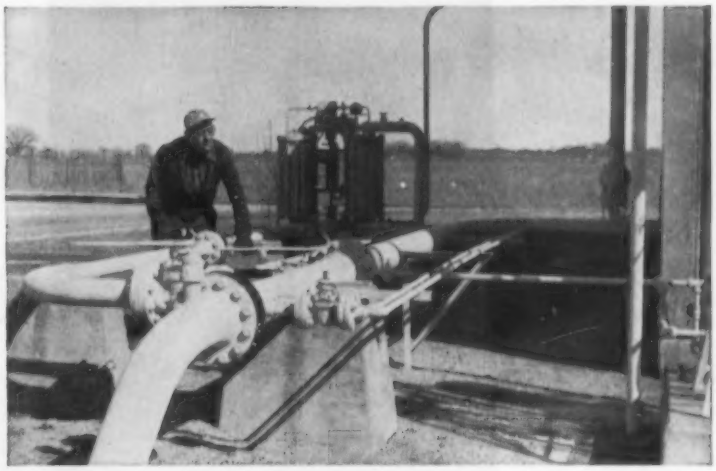
DRY natural gas to a -50° F. dewpoint before pressurizing for underground storage

185 million cubic feet of gas is stored underground in high pressure pipe sections by Northern Illinois Gas Company

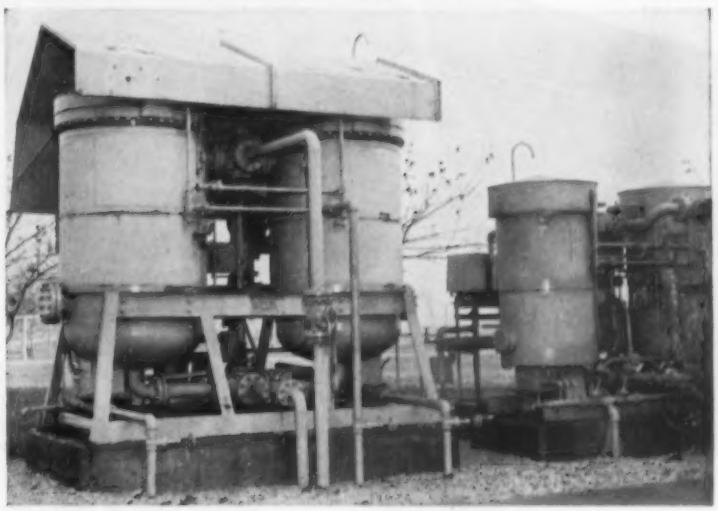
TEN underground storage fields, strategically located throughout its service area, are maintained by Northern Illinois Gas Company for possible emergency use.

Lectrodryers DRY and Lectrofilters* CLEAN the natural gas before it is compressed for storage. Thus, when the gas is withdrawn from the high pressure storage units, there's no moisture to cause valve freeze-ups. Gas feeds into the lines without interruption.

Whatever your DRYing problem—involving air, gases or organic liquids, at low or high pressures, in small or large volumes—there's a Lectrodryer able to handle it. Write for literature, telling us what you want to DRY. Pittsburgh Lectrodryer Company, 307 32nd Street, Pittsburgh 30, Pennsylvania (a McGraw Electric Company Division).



This BWC-150 Lectrodryer handles the DRYing at the 4,800,000 cu. ft. Rock Falls plant.*



A BWC-1500 and BWC-750 Lectrodryer serve the 120,000,000 cu. ft. Mt. Prospect field.

In England: Birlec, Limited, Tyburn Road, Erdington, Birmingham.
In France: Stein et Roubaix, 24 Rue Erlanger, Paris XVI.
In Belgium: S. A. Belge Stein et Roubaix, 320 Rue du Moulin, Bressoux-Liege.

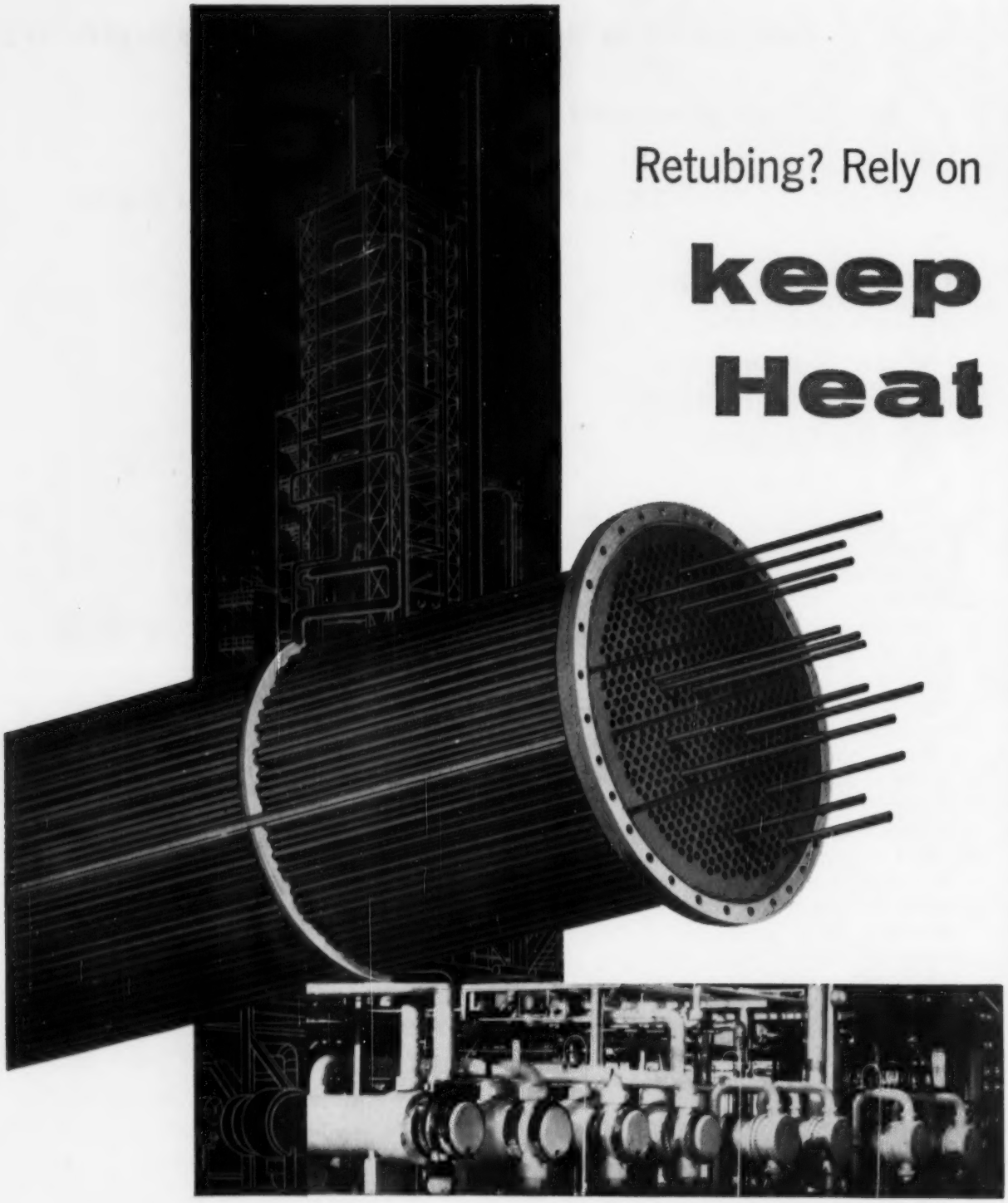
LECTRODRYERS DRY WITH ACTIVATED ALUMINAS

LECTRODRYER

* REGISTERED TRADEMARK U. S. PAT. OFF.

Retubing? Rely on

keep Heat



First for Lasting Quality—from Mine to Market!

Phelps Dodge COPPER-BASE ALLOY Tubes to

your Exchangers On-Stream!

- ✓ **Complete line of copper-base alloys** including Bi-Metal combinations to meet special corrosive conditions.
- ✓ **Speedy delivery** from strategically-located warehouses.
- ✓ **Careful analysis of your corrosion problems** by experienced engineering staff.
- ✓ **Quality-controlled fabrication** to assure finest tube properties.
- ✓ **Information and sales service** available from nearest Phelps Dodge district office.*

PHELPS DODGE COPPER PRODUCTS CORPORATION
LINE TO MEANS
REG. U. S. PAT. OFF.

PHELPS DODGE COPPER PRODUCTS CORPORATION

*SALES OFFICES: Atlanta, Birmingham, Ala., Boston, Buffalo, Charlotte, Chicago, Cincinnati, Cleveland, Dallas, Detroit, Fort Wayne, Greensboro, N. C., Houston, Jacksonville, Kansas City, Mo., Los Angeles, Milwaukee, Minneapolis, New Orleans, New York, Philadelphia, Pittsburgh, Portland, Ore., Richmond, Rochester, N. Y., San Francisco, St. Louis, Seattle Washington, D. C.

For more data on advertised products, use Readers' Service Cards, last page.

16,700 pounds of fork lift and steel wire roll smoothly over this Multigrip protected aisle. In the past, the 2-inch-thick wooden flooring required repairs two or three times a week. In the eight years Multigrip has been on the job, there hasn't been a single hole or worn spot.

Perfect traction allows this heavily-laden fork lift to roll easily from a concrete ramp onto the Multigrip Floor Plate aisle. Even after eight years, the floor plate has shown hardly a sign of wear.

Multigrip Floor Plate solved a tough maintenance problem

How much does it cost to repair wooden flooring two or three times weekly? "Too much," said a Midwestern metal fabricating company. Fork lifts in their plant, loaded with steel wire for a grand total of 16,700 pounds, were breaking through 2-inch-thick wooden flooring regularly.

Eight years ago, 12,000 square feet of USS Multigrip Floor Plate were used to surface all aisles and ramps used by the heavily-laden trucks. To date, maintenance has been limited to replacement of a few bolts used to fasten the Multigrip to wooden flooring beneath. Installation took only a few working days, including measuring, cutting turns, laying and seam-welding. The Maintenance Supervisor says, "Since I installed Multigrip Floor Plate, I haven't had to patch a hole and haven't had to reweld seams, smooth off risers or anything. There isn't a thing except steel floor plate that could carry lift-loads of 16,700 pounds without damage."

Multigrip Floor Plate can be a plus factor on your maintenance budget, too. These tough steel plates with their flat-topped risers stay in service for years with hardly a sign of wear. They provide "safe-tread" traction for both feet and wheels, even when wet. Since oil and grease can't possibly soak in, a broom is all that's needed for cleaning. Multigrip is available in large plates for economical installation and may be bent or formed where necessary. Make your plant safer while giving your budget a break by protecting ramps, stairs, aisles, platforms and floor areas with USS Multigrip Floor Plate.

UNITED STATES STEEL CORPORATION, PITTSBURGH • COLUMBIA-GENEVA STEEL DIVISION, SAN FRANCISCO
TENNESSEE COAL & IRON DIVISION, FAIRFIELD, ALA. • UNITED STATES STEEL SUPPLY DIVISION, CHICAGO
UNITED STATES STEEL EXPORT COMPANY, NEW YORK

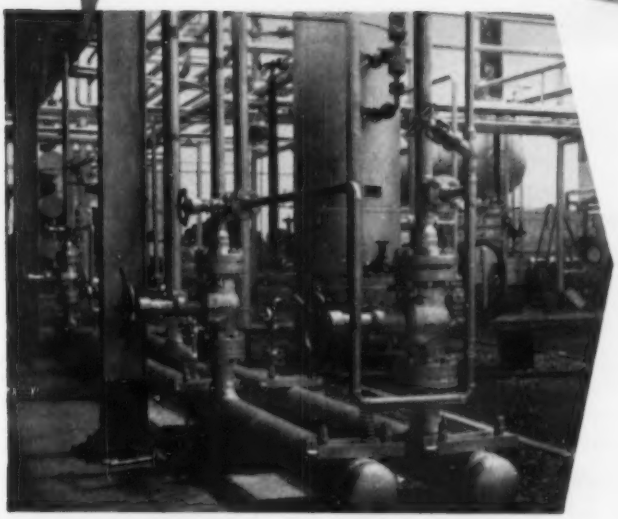
6-1084

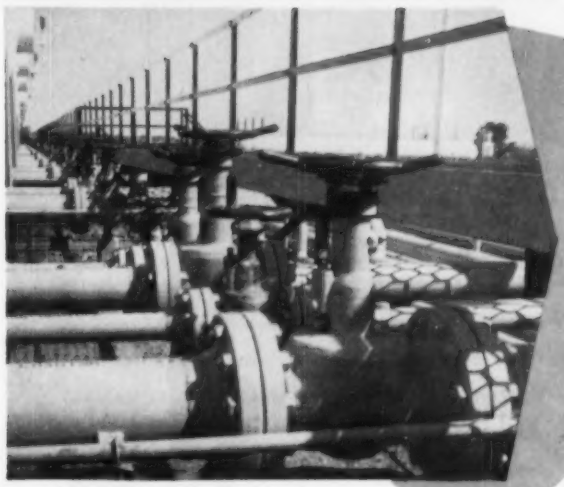
USS multigrip FLOOR PLATE

Sold by leading distributors from coast to coast

UNITED STATES STEEL

JOIN THE TREND TOWARD ORBIT FORGED STEEL VALVES . . .





Orbit's popularity is built on performance and quality.

They provide:

1. **Positive seating without lubrication**
2. **Long years of service with low cost maintenance**
3. **Easy operation**

Countless thousands of ORBIT Valves are now doing service for manufacturers of Hydrocarbons, Chemicals, Fertilizers and Synthetic Rubber. They are engineered and designed to hold volatile liquids. Made in Full Round Opening: Flanged and Screw End; Venturi Opening: Flanged End only.

● *See 23rd (1956) Edition of Refinery Catalog for details.*

ORBIT VALVES ®

ORBIT VALVE COMPANY

P. O. BOX 699 • TULSA 1, OKLAHOMA

BRANCHES

HOUSTON, TEXAS
407 Velasco
(Serving the Gulf Coast)

CASPER, WYOMING
247 West First Street
(Serving the Rocky Mountain States and Canada)

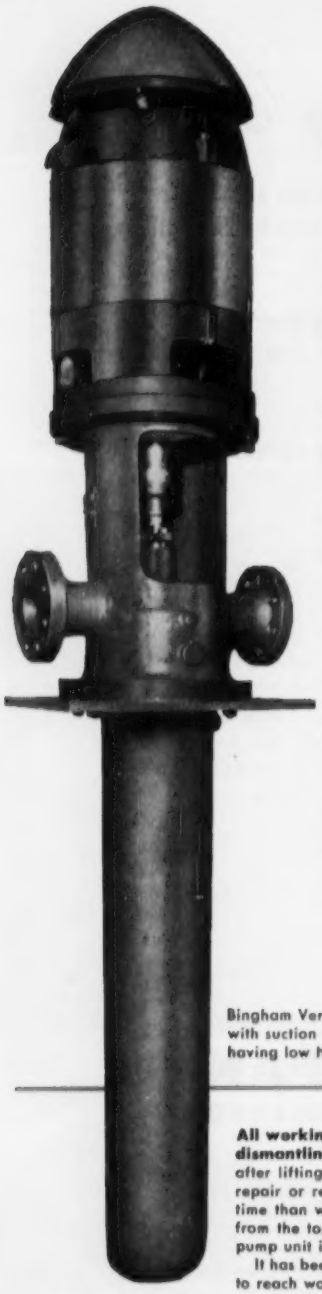
ODESSA, TEXAS
402 West County Road
(Serving West Texas)

Export Representative: 500 Fifth Ave., New York 36, N. Y. • Ph. BRyant 9-2236

Canadian Representative: 536 8th Ave. West, Calgary, Alberta, Canada • Ph. 3-0437

For more data on advertised products, use Readers' Service Cards, last page.

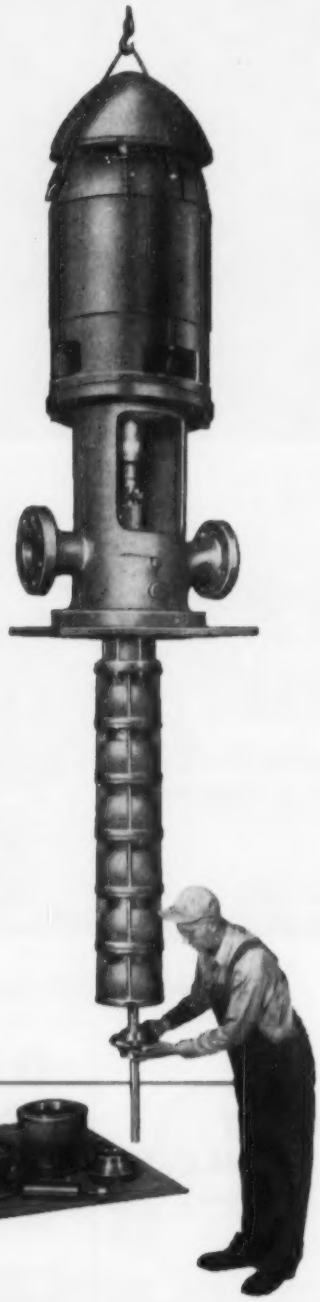
NEW! Bingham ALL WORKING PARTS



Besides bottom dismantling, which in itself greatly reduces maintenance time when attention is required, this new Bingham pump incorporates advanced design features which minimize maintenance, reducing the need for periodic inspection.

For example, all intermediate bearings (supplied of appropriate material for different pumpages) are forced-lubricated by the pumpage. Bottom bearing is lubricated even if the pump runs dry for short periods. This *dependable* lubrication greatly prolongs the life of bearings, which in conventional pumps are frequently the cause of maintenance shutdowns.

Wherever it has been installed, the new Bingham VCP Pump has given trouble-free service—plus unsurpassed smooth operation with no vibration. Available for any capacity or head. Write your nearest Bingham office for additional information, and Bulletin 109.

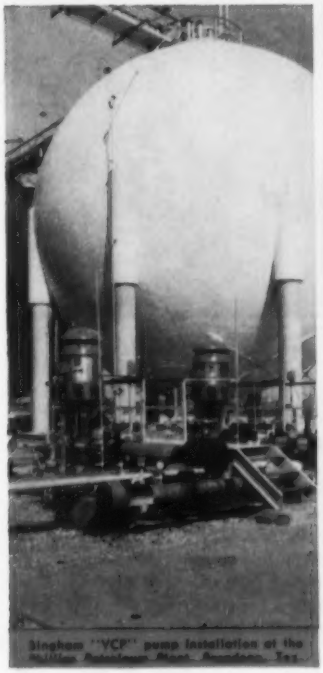


Bingham Vertical VCP assembled with suction well for installations having low NPSH conditions.

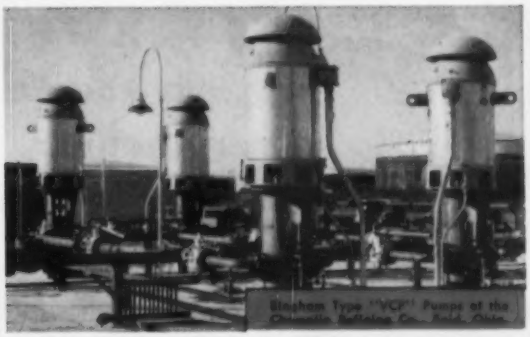
All working parts of pump easily accessible with bottom dismantling. One man can service the Bingham VCP Pump after lifting pump from well. By dismantling from the bottom, repair or replacement of any part can be made in much less time than with conventional pumps (where dismantling begins from the top, necessitating removal of driver and head before pump unit is accessible).

It has been estimated by various operators that time required to reach working parts has been reduced as much as 50%.

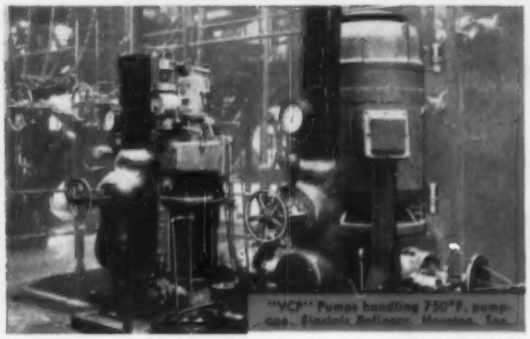
VCP VERTICAL PUMP FOR LOW NPSH
ACCESSIBLE WITH BOTTOM DISMANTLING



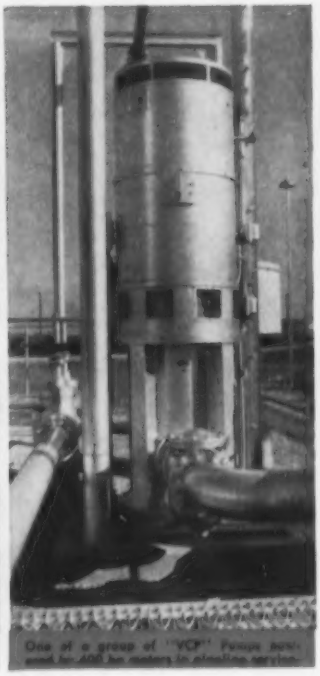
Bingham "VCP" pump installation at the Mellon Petroleum Plant, Beaumont, Tex.



Bingham Type "VCP" Pumps at the Cleveland Refining Co., Lorain, Ohio.



"VCP" Pumps handling 750°F. pump-age, Sinclair Refinery, Houston, Tex.



One of a group of "VCP" Pumps motor-powered by 600 hp motors in pipeline service.

Partial list of major oil companies with Bingham "VCP" Pumps in operation or on order:

Ashland Oil & Refining Co.	Phillips Petroleum Co.	Chemical Construction Co.
Gulf Oil Corporation	American Cyanamide Co.	Champlin Refining Co.
Sinclair Oil & Refining Co.	ESSO-Standard Oil of N. J.	Pacific Gas & Electric Co.
Sun Oil Company	British American Oil Co., Ltd.	Socony-Vacuum
The Texas Company	Lakehead Pipe Line Co.	Aerojet General Corp.
Imperial Oil Co., Ltd.	Creole Petroleum Co.	Great Lakes Pipe Line Co.
Shell Oil Company	Humble Oil Company	Kaneb Pipe Line
Deere & Company	Standard Oil Co. of Indiana	Buckeye Pipe Line Co.

Bingham SINCE 1921

DOUBLE VOLUTE PUMPS RADIAL BALANCE

BINGHAM PUMP COMPANY
General Offices: 2800 N.W. Front Avenue, Portland 10, Oregon
Factories: Portland, Ore. • Vancouver, B. C., Canada

SALES AND SERVICE OFFICES

BOSTON, MASS.	NEW YORK CITY, N.Y.
CHICAGO, ILL.	PHILADELPHIA, PA.
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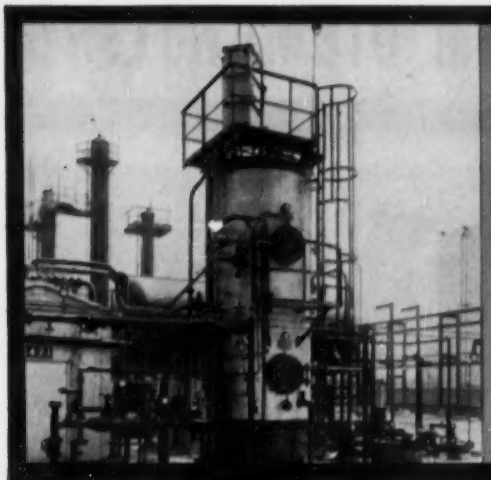
DALLAS, TEXAS	SAN FRANCISCO, CALIF.
DENVER, COLO.	SEATTLE, WASH.
HOUSTON, TEXAS	ST. LOUIS, MO.
KANSAS CITY, MO.	ST. PAUL, MINN.
LOS ANGELES, CALIF.	TULSA, OKLA.
NEW ORLEANS, LA.	TORONTO, ONT., CAN.

VANCOUVER, B. C., CAN.

For more data on advertised products, use Readers' Service Cards, last page.

DO YOU CAUSTIC WASH?



PETRECO

ELECTROFINING
will help you do it easier, cheaper, faster and will yield better products

ELECTROFINING IS EASIER

. . . because it is continuous, automatically precision-controlled and a once-through, one-pass treatment. If you've been caustic washing by the conventional, time-consuming multiple-vessel method, you won't believe how easily Electrofining functions until you see it operate.*

ELECTROFINING IS CHEAPER

. . . because it may use only one small vessel compared with three or four large vessels in conventional systems. It can be installed in a ground area approximately twelve feet by thirty feet. The piping, pumps and similar appurtenances are proportionately less. Electrofining requires a minimum of caustic and eliminates product losses. Electrofining equipment can be installed on a sale or rental basis.*

ELECTROFINING IS FASTER

. . . because it delivers a sharp, clean separation of the hydrocarbon and caustic-wash phases. Chemical entrainment is reduced to the point that water-wash often is unnecessary. The finished product travels from tower to market with only the briefest treating period, and settling time is a matter of hours, not days, as it is with multiple-vessel treating.*

ELECTROFINING DELIVERS BETTER PRODUCTS

. . . because the fast, clean break prevents reaction products formed by caustic and tarry acids from causing a haze problem. Spent caustic, metals, mercaptans and other impurities are removed so thoroughly that the Electrofined product meets all market specifications such as Federal Alkalinity Tests, etc. Total metals in the Electrofined product average less than 1 PPM.*

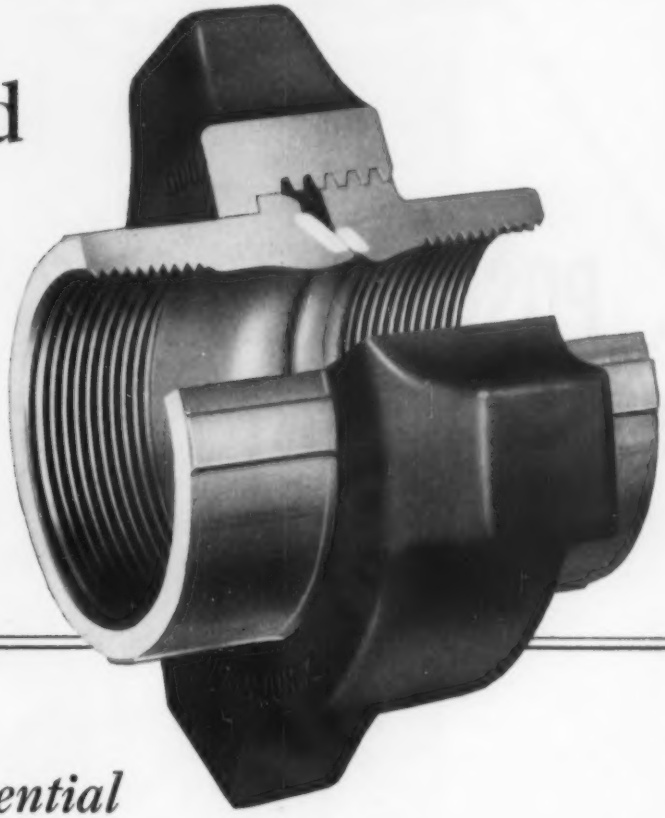
Your Petreco service engineer will arrange for you to see an Electrofiner in action, and give you complete facts and figures on its operation.

PETRECO
A DIVISION OF PETROLITE CORPORATION
3202 S. Wayside Drive, Houston 1, Texas
1390 East Burnett St., Long Beach 7, California

SPECIALIZED ELECTRIC PETROLEUM TREATING
Desalting • Dehydrating • Caustic Washing • Acid Contacting • Doctor Treating • Sweetening • Naphthenic Acid Removal • Sediment Removal

PT 6-a

Rockwood 603A Tri-Lug Union



Hardness Differential means quick make-up without galling

Strength, acme speed threads, corrosion-resistance, interchangeability — name it and the Rockwood 603A Tri-Lug Union has it.

Hardness differential assures tight seal

The male seat of the 603A is especially treated to make it 150 Brinell harder than the female seat. That means no galling in "make-up." Both seats are made of corrosion-resistant AISI molychrome steel.

Acme Speed Thread and nut extra hard

The quick opening acme threads and nut are also especially hardened. The lugs will not deform — even when hit with a hammer! And one lug is in position at all times. These speed threads also assure quick "making" and "breaking" in service.

"Rockwoodizing" assures corrosion protection

A special coating process, applied after threading, protects the entire union including the quick-opening acme thread from corrosion.

Exclusive cold forging process assures interchangeability

Rockwood's exclusive cold forging process results in completely interchangeable parts and higher resistance to tough working conditions of expansion, contraction, shock, jar and vibration.

Get the Union with hardness differential

Write for complete information. Mail coupon today. The Rockwood 603A Union is tested and listed by Underwriters' Laboratories, Inc.

ROCKWOOD SPRINKLER COMPANY

Distributors in all principal industrial areas

ROCKWOOD SPRINKLER COMPANY
1461 Harlow Street,
Worcester 5, Mass.

Please send me prices and further data on the Rockwood Union 603A. I would also like the name of the nearest Rockwood distributor.

Name.....

Title.....

Company.....

City.....Zone....State.....

For more data on advertised products, use Readers' Service Cards, last page.

POSITIVE DISPLACEMENT NO STUFFING BOX

Specify Lapp Auto-pneumatic PULSAFEEDER

. . . for Automatically Controlled Metering of Liquids

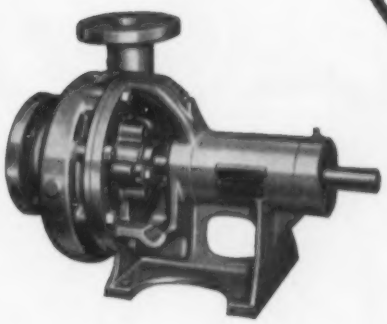
The outstanding features of the Lapp "Auto-Pneumatic" Pulsafeeder make possible continuous automatic processing of liquids which cannot be satisfactorily handled by plunger-type metering pumps. The "Auto-Pneumatic" Pulsafeeder is a piston-diaphragm pump providing positive displacement without the problems of a stuffing box. A hydraulically balanced Pulsafeeder diaphragm isolates the product from the working parts of the pump, preventing product leakage or contamination. With pneumatic instrument control, the pumping rate of the "Auto-Pneumatic" Pulsafeeder automatically adjusts from zero to full capacity. Manually adjustable models also available.

WRITE FOR BULLETIN 440 *with typical applications, flow charts, description and specifications of models of various capacities and constructions. Inquiry Data Sheet included from which we can make specific engineering recommendation for your processing requirement. Write Lapp Insulator Co., Inc., Process Equipment Division, 653 Wilson Street, Le Roy, New York.*

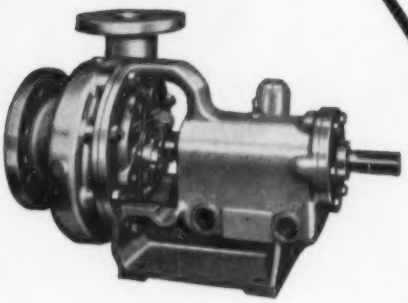
Lapp

Mr. Engineer: Cut Your Pump Inventory—Reduce Costs With These New, Proved Pumps

PEERLESS
CHEMICAL PROCESS PUMPS



type **DL**
grease lubricated housing



type **DM**
oil lubricated housing

Here is
INTERCHANGEABILITY IN ACTION—

Interchangeability of component parts for DL-DM pumps is graphically shown by this slide selector. Write for your FREE copy. It shows how liquid end components are accommodated on either grease lubricated or oil lubricated bearing housings. Also provides quick reference to pump specifications and performance characteristics.

a new concept of economy through interchangeability of components!

PEERLESS
type DL & DM PROCESS PUMPS ALSO FEATURE:

ACCESSIBILITY—Through ease of assembly and disassembly if and when required. **DURABILITY**—Through use of any machinable metal as materials of construction. **SERVICEABILITY**—Through designs that feature maximum ease of maintenance. **INTERCHANGEABILITY**—Through a choice of semi-open or enclosed impellers, oil or grease lubrication, air-or water-cooled back plates and bearing housings. **RELIABILITY**—Through the high performance standards set for these pumps, proving more than ever before, that Peerless Builds Dependable Pumps. **AVAILABILITY**—Through shipment from stock of both complete pumps and pump components.

Other pertinent Type DL-Type DM facts:

Peerless Type DL and Type DM process pumps are available in 1", 2", 2½" and 3" sizes on an 8½" frame and in 1", 2", 2½", 3" and 4" sizes on a 10½" frame. **CAPACITIES**: up to 800 gpm. **HEAD RANGE**: up to 430 feet. **DRIVES**: motor or steam turbine. **TEMPERATURE RANGE**: grease lubricated housing up to 250°F.; oil lubricated housing up to 450°F. **WORKING PRESSURES**: up to 400 psig.

Write for your Slide Selector now. Use coupon for quick action.

PEERLESS PUMP

PEERLESS PUMP DIVISION
FOOD MACHINERY AND CHEMICAL CORPORATION

Factories: Indianapolis 8, Indiana and Los Angeles 31, California
Offices: New York, Chicago, St. Louis, Atlanta, Lubbock and Plainview, Texas; Fresno, Los Angeles, Phoenix, Albuquerque.
Distributors in Principal Cities. Consult your local Telephone Directory.

fmc

PEERLESS PUMP DIVISION
Food Machinery and Chemical Corporation
301 West Avenue 26, Los Angeles 31, California

Please send chemical process pump selector DR-1

Name_____

Company_____

Address_____

City_____ State_____

Petr

For more data on advertised products, use Readers' Service Cards, last page.

New! The Sherman Major Power Digger

with Many Advanced Features to Increase Versatility and Earning Power

The all new Sherman Major Power Digger has been engineered to take full advantage of the ruggedness and economy of the Fordson Major Diesel Tractor. This heavy-duty unit will dig 12 feet below grade, reach 18 feet 3 inches behind the tractor rear axle, dig throughout a swing arc of 180° and will carry a full bucket to a height of 8 feet 8 inches for loading trucks.

Additional features of the new Sherman Major Power Digger include twin crowd cylinders, heavy steel plate construction, large diameter hinge pins, heavy steel castings, replaceable hardened steel bearings at hinge points, and a newly designed dipstick, boom, cylinders, bucket and sub-frame assembly.

Write for bulletin No. 3341

See the Sherman Major Power Digger soon at your local **FORD TRACTOR DEALER**

Sherman
PRODUCTS, INC.
ROYAL OAK, MICHIGAN
POWER DIGGERS* • FRONT END LOADERS • FORK LIFTS

*Designed, Engineered and Manufactured jointly by Sherman Products, Inc., Royal Oak, Michigan. Wain-Roy Corporation, Hubbardston, Mass.

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There's **MORE** Cooling Surface in these deep-ribbed **MOTORS**

No Day is FRYDAY with these Allis-Chalmers MOTORS

● Frying of insulation is impossible under normal conditions with the extra-large cooling surface of Allis-Chalmers rib-type TEFC motors. The result—you expect and get longer motor life.

The engineered partner of A-C motors is Allis-Chalmers control.

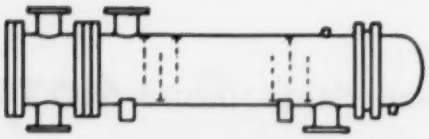
Get Complete Information

As a new machinery component or as replacement, specify Allis-Chalmers. Discuss your particular application with your nearby A-C distributor, A-C district office, or write Allis-Chalmers, General Products Division, Milwaukee 1, Wisconsin.

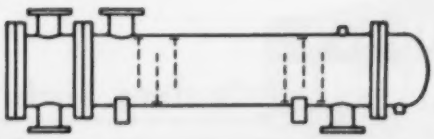
ALLIS-CHALMERS

A-C ALLIS-CHALMERS

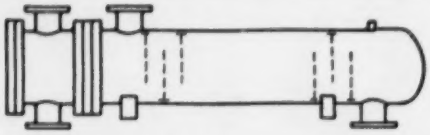
A-4853



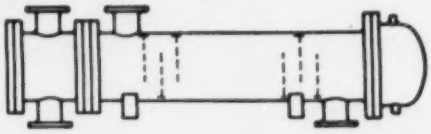
Type SG straight tube, outside packed lantern gland design. Eliminates undetected fluid inter-leakage.



Type S pull-through floating head design. For condensing, heating services . . . easy maintenance.



Type R U-tube design. Low cost construction, for non-fouling service.



Type ST conventional straight tube, split ring, floating assembly construction.

HOW YOU CAN SAVE WITH Whitlock Standardized Heat Exchangers!

SAVE WORK . . . "prints for approval" can be supplied quickly for piping and other layouts.

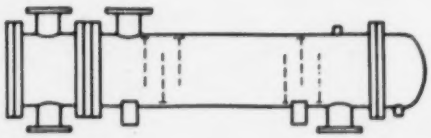
SAVE ENGINEERING COSTS . . . our engineers will help you select a standard design suited to your requirements.

SAVE DELIVERY TIME . . . many units can be manufactured promptly from stock materials and subassemblies. Also, completed units are often in stock for immediate shipment.

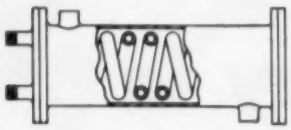
SAVE ON REPAIRS . . . readily available duplicate parts simplify emergency repairs . . . reduce downtime.

SAVE ON FIRST COSTS . . . our long manufacturing experience plus quantity produced sub-assemblies and quantity purchasing of materials reduce the unit cost of Whitlock Standard Exchangers. These savings are reflected in our current prices.

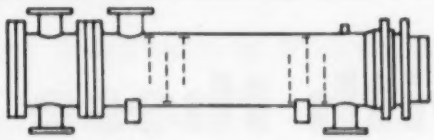
Compare costs . . . compare *savings*. It pays to consider Whitlock Standard Exchangers *first*. Send for Bulletin 250. The Whitlock Manufacturing Co., 75 South St., West Hartford 10, Conn.



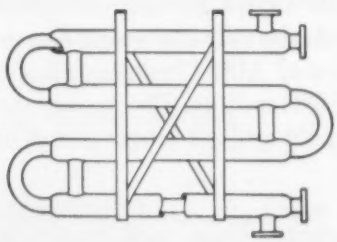
Straight tube, fixed tube sheet design. Types V and V-1—for easy mechanical cleaning.



Type C coil type heat exchangers. For high tube side pressures.



Floating head heat exchangers. Type SO with outside packed head—no concealed, bolted and gasketed joints.



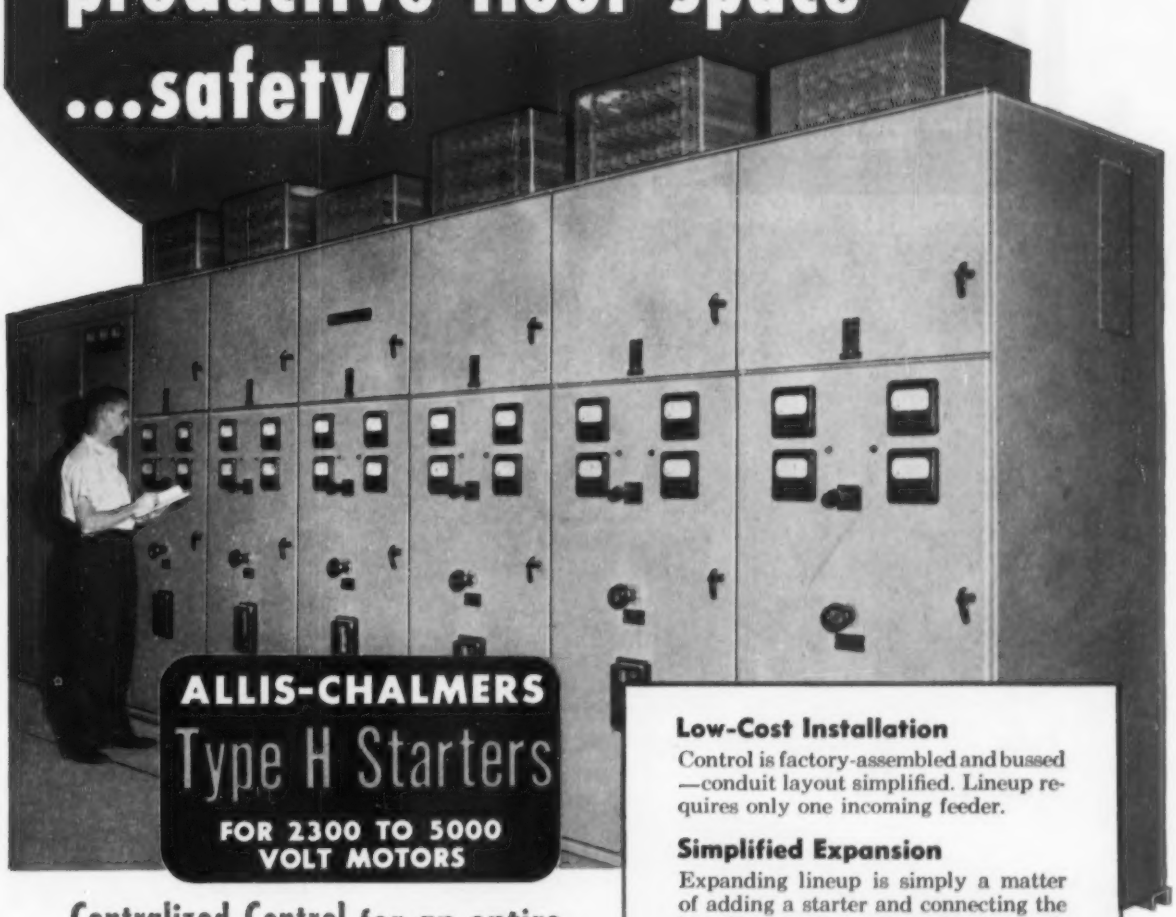
Double pipe heat exchangers. For countertemperature flow conditions and low flow rates.

Whitlock

Designers and builders of bends, coils, condensers, coolers, heat exchangers, heaters, piping, pressure vessels, receivers, reboilers.

You get **MORE** when it's Built by Allis-Chalmers

...more convenience... productive floor space ...safety!



ALLIS-CHALMERS
Type H Starters
FOR 2300 TO 5000 VOLT MOTORS

Centralized Control for an entire plant or department

Time-saving, cost-cutting convenience in planning, buying, installation, and operation are all yours with Allis-Chalmers centralized high voltage control. In addition, the factory-assembled lineup, installed in an out-of-the-way location, releases critical floor space for profitable production. From the safety standpoint, the control operates in cleaner atmosphere and can be isolated from unauthorized personnel when located in a separate control room or area.

Low-Cost Installation
Control is factory-assembled and bussed —conduit layout simplified. Lineup requires only one incoming feeder.

Simplified Expansion
Expanding lineup is simply a matter of adding a starter and connecting the bus. Each starter unit is self-contained.

Attractive Appearance
Uniformity of cubicles presents modern, streamlined appearance. Concentrating control in one lineup eliminates cluttered look.

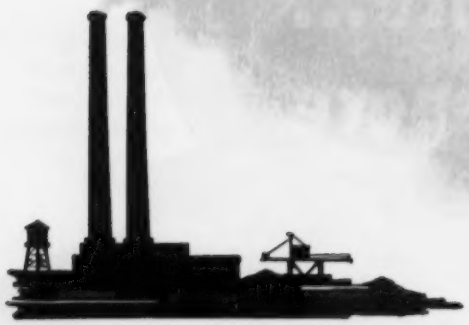
One Company Responsibility
Responsibility for assembling proper devices and for control performance rests with Allis-Chalmers.

LIVE BETTER ELECTRICALLY

For complete information, see your A-C representative or write Allis-Chalmers, General Products Division, Milwaukee 1, Wisconsin.

ALLIS-CHALMERS

A-4978



Never Again need this happen

Here is a portion of a landscape in which the soil was completely poisoned decades ago by sulfur fumes from metallurgical furnaces. Not a tree or shrub, not a blade of grass, not even the lowliest weed grows here. A CHEMICO plant would have saved this ruined countryside by capturing the poisonous waste fumes and converting them into sulfuric acid.

Today, CHEMICO Sulfuric Acid Plants are performing this service all over the country, where sulfur-bearing gases from metallurgical or other industrial operations constitute a menace.

In doing so, these CHEMICO Sulfuric Acid Plants are *doubly* paying back their cost . . . by providing a source of income . . . by preserving our priceless soil.

CHEMICAL CONSTRUCTION CORPORATION

Designers and constructors of complete plants and facilities for the chemical and petrochemical processing industries for over 40 years

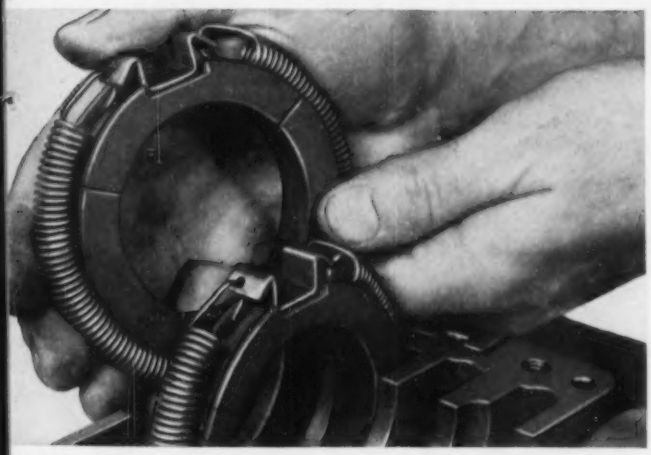
525 WEST 43RD STREET, NEW YORK 36, NEW YORK

Cable Address: Chemiconst New York • Technical Representatives: Cyanamid Products Ltd., London South African Cyanamid (Pty) Ltd., Johannesburg

CC-916

On all General Electric High-speed Turbines,

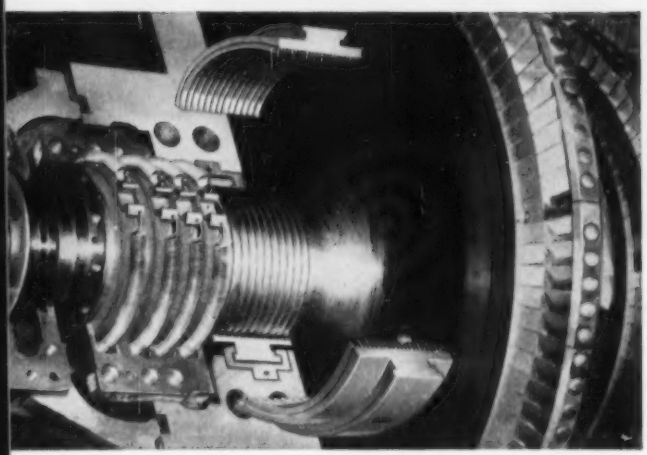
Well-designed, efficient seals...



Highly efficient, easily-replaced carbon packings

For the most effective shaft-end sealing, well-designed, low-cost carbon packings are used on G-E High-speed Turbines to seal steam pressures up to 75 psig. Made of non-galling, self-lubricating carbon-graphite, these segmental rings have high mechanical strength in the small sizes used, assuring long life under normal operating conditions. A garter spring in an offset "V" groove holds each ring together and presses it firmly against the side of the chamber, forming a tight seal. This unique arrangement permits the rings to support their own weight and to adjust themselves to the shaft position, thereby reducing wear and increasing the life of the seal. The rings are contained in compact external packing boxes, and can be easily inspected or replaced without breaking the horizontal joint of the wheel casing.

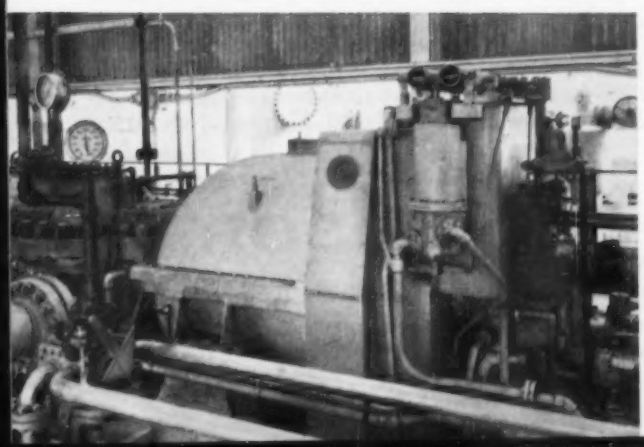
cut steam leakage...



Reliable, long-life metallic-labyrinth seals

To effectively minimize shaft-end steam leakage where shell pressures exceed 75 psig, segmental, high-low tooth metallic-labyrinth seals are used in combination with carbon packing. Between stages, straight-tooth metallic-labyrinth seals are always used. For maximum seal efficiency, minimum clearances between the teeth and the shaft are maintained by precision-machined hook fits in the packing housing. Shaft scoring is practically eliminated since the leaded-bronze segments are spring-backed and can move outward should there be accidental contact with the shaft. When unbalanced steam pressure forces axial movement of the seals, the shoulders of the rings and the housing engage to form a tight steam seal. All labyrinth seals are designed to compensate for thermal expansion, thus assuring a most efficient steam seal at operating temperatures.

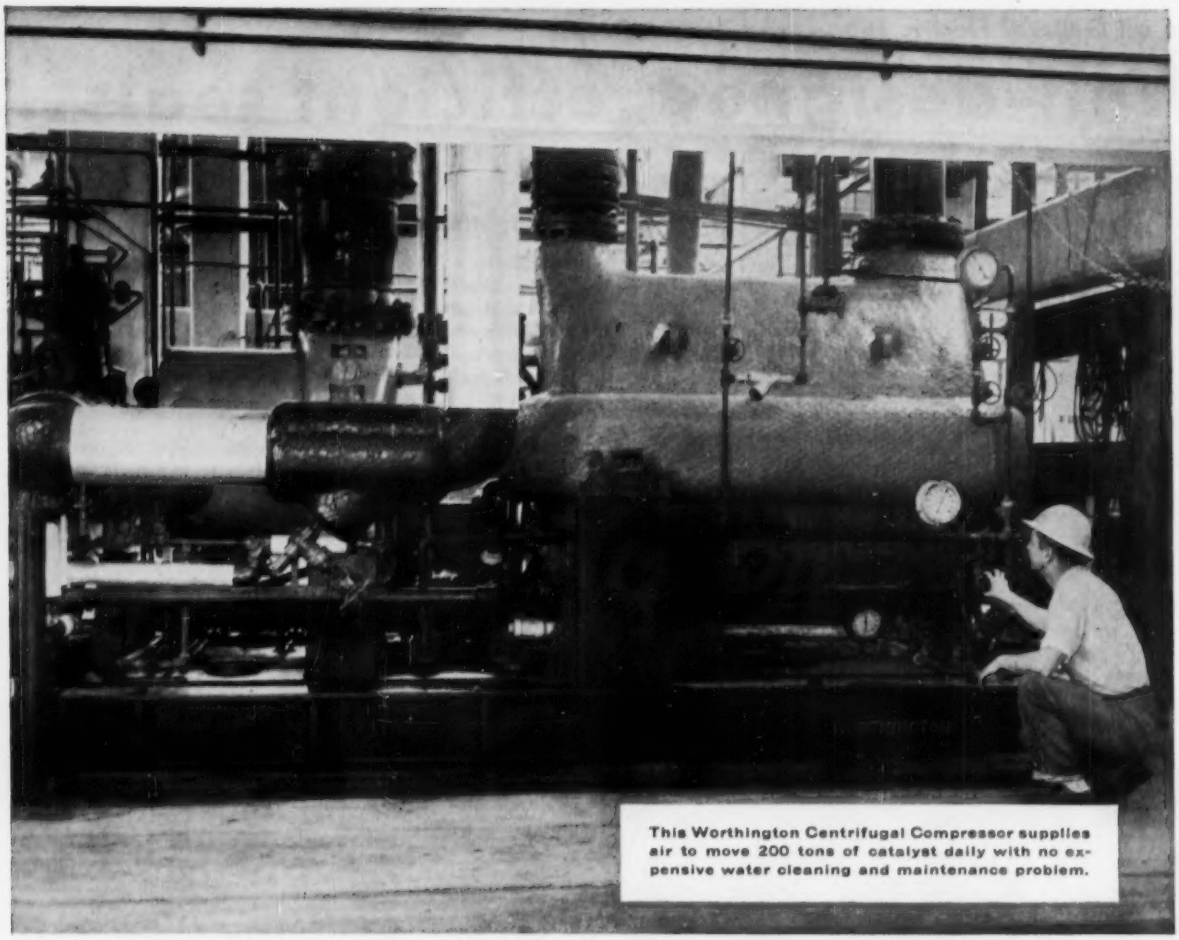
reduce maintenance costs



The careful design and manufacture of these steam seals is your further assurance of low maintenance and consistent reliability of G-E High-speed Turbines. Why not check into the many other sound design features built into these mechanical drives? Your Apparatus Sales Representative will be glad to explain the many benefits they offer to your operation. Contact him for further information or write for Bulletin GEA-6232, General Electric Company, Section 241-7, Schenectady, N. Y.

Progress Is Our Most Important Product

GENERAL ELECTRIC



This Worthington Centrifugal Compressor supplies air to move 200 tons of catalyst daily with no expensive water cleaning and maintenance problem.

Process compression without diaphragm and water supply problems

Perhaps your processing can be compared to this operation at Cities Service Refining, where heavy gas oils are catalytically cracked into fuel gas, propylene, and butylene for alkylate and butadiene production, high octane gasolines, and light fuel oils.

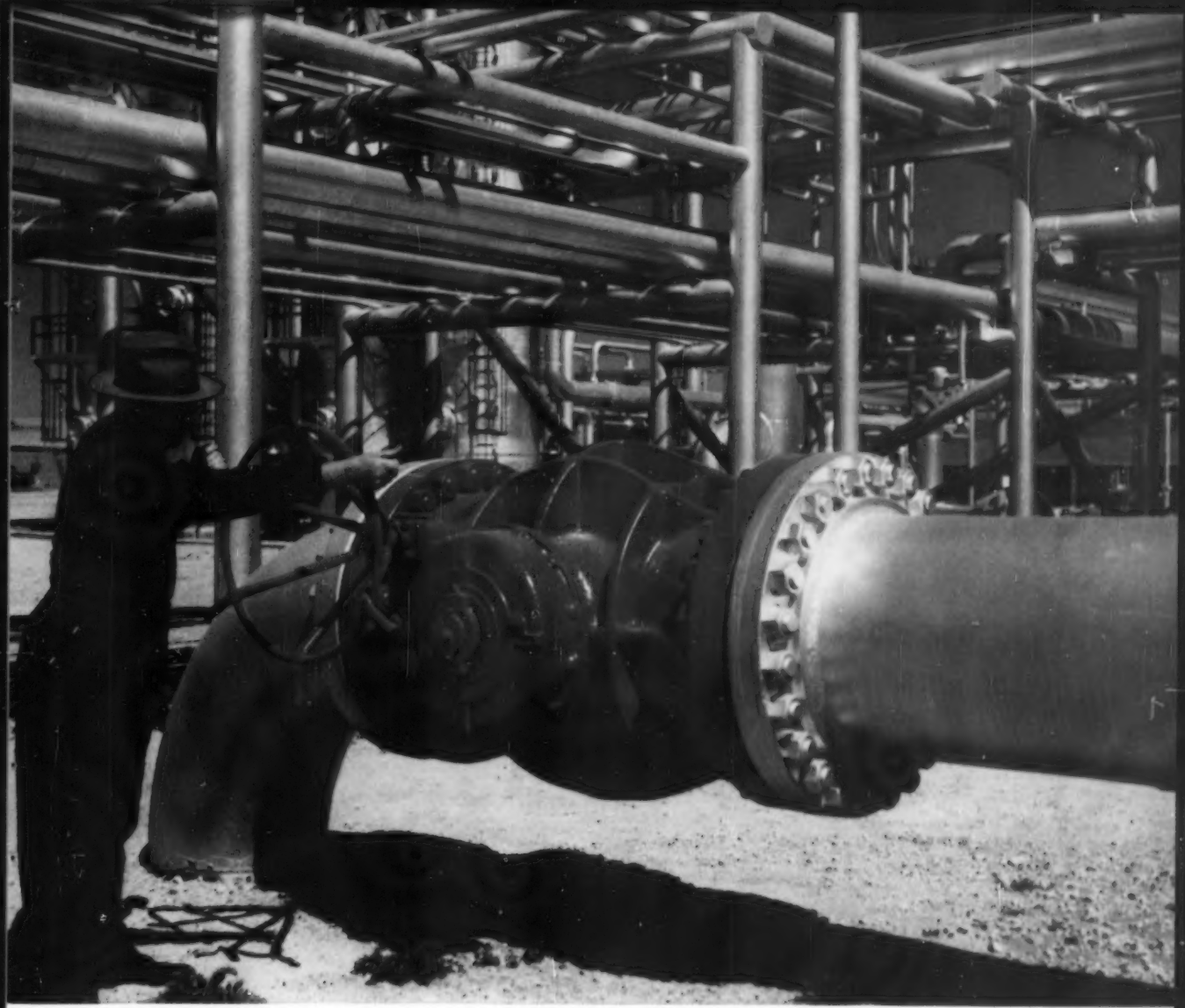
Here's an example of low-cost, high-volume processing, with a Worthington GUR centrifugal unit compressing the air to move 200 tons of catalyst per day in a trouble-free, economical manner.

The costly diaphragm and exchanger maintenance problem inherent in the operation of an ordinary compressor is unknown with the Worthington GUR. At Cities Service's Lake Charles refinery, the Worthington centrifugal operates with 95° F. air at 100% relative humidity and 14.5 psia suction pressure, and discharges at 61 psia, 450° F., with a capacity of 4,875 CFM. The compressed air is used to transfer and aerate the catalyst. The temperature of the compressed air is controlled by means of interstage liquid injection, an exclusive development that reduces the heat of compression without employing external heat exchangers. It is powered by a dependable Worthington steam turbine. Cities Service reports, "Governing and control are excellent, and in all other respects it is very satisfactory."

If you'd like the same satisfaction for your process compression or refrigeration, write your Worthington District Office or Worthington Corp., Air Conditioning and Refrigeration Division, Section A6101, Harrison, New Jersey.

A-6.101

WORTHINGTON



How much does a valve cost?

A valve that fails in an emergency can cost millions of dollars in equipment and product loss. In any key spot, Rockwell-Nordstrom lubricated plug valves are your best insurance against this kind of loss. They operate instantly; they shut off positively; and they *stay* efficient. These are facts you can depend on—they have been *proven* through 40 years of outstanding performance.

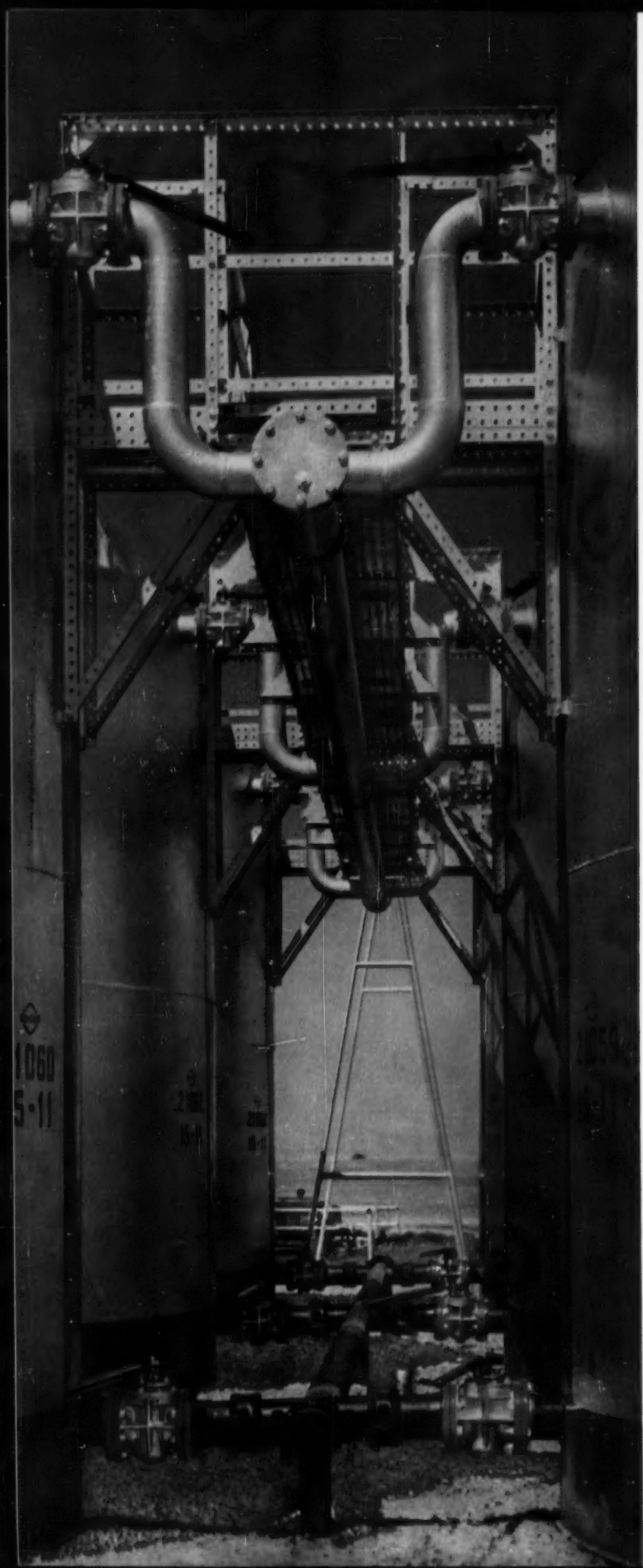
Rockwell-Nordstrom valves are available in a complete range of sizes and pressure ratings. They cost no more to buy, often less, than ordinary valves . . . and their dependability cannot be matched by any valve at any price. For more information, write: Rockwell Manufacturing Company, Pittsburgh 8, Pennsylvania.

Available at leading suppliers . . . everywhere.

ROCKWELL-Nordstrom **VALVES**

Lubricant Sealed for Positive Shut-off

40th Year *of lubricated plug valve leadership*



Liquid flow control... at its best

Rockwell-Nordstrom valves' proven dependability and economy keep costs down on *any* liquid service. Pressurized lubricant sealing for really positive shut-off, plus smooth quarter-turn operation, assures precise flow control on complex manifolds or remote pipe line valves. Because Rockwell-Nordstrom lubricants eliminate metal-to-metal friction, trouble doesn't have a chance to start. This means that yearly cost is much lower than ordinary valves. Original cost is no more, and often less.

Rockwell-Nordstrom, the original and most complete line of lubricated plug valves, are available in steel, semi-steel, stainless steel and special alloys for a complete range of pressures and temperatures. For more information write: Rockwell Manufacturing Company, Pittsburgh 8, Pennsylvania.

Available at leading suppliers . . . everywhere.

ROCKWELL-
Nordstrom
VALVES

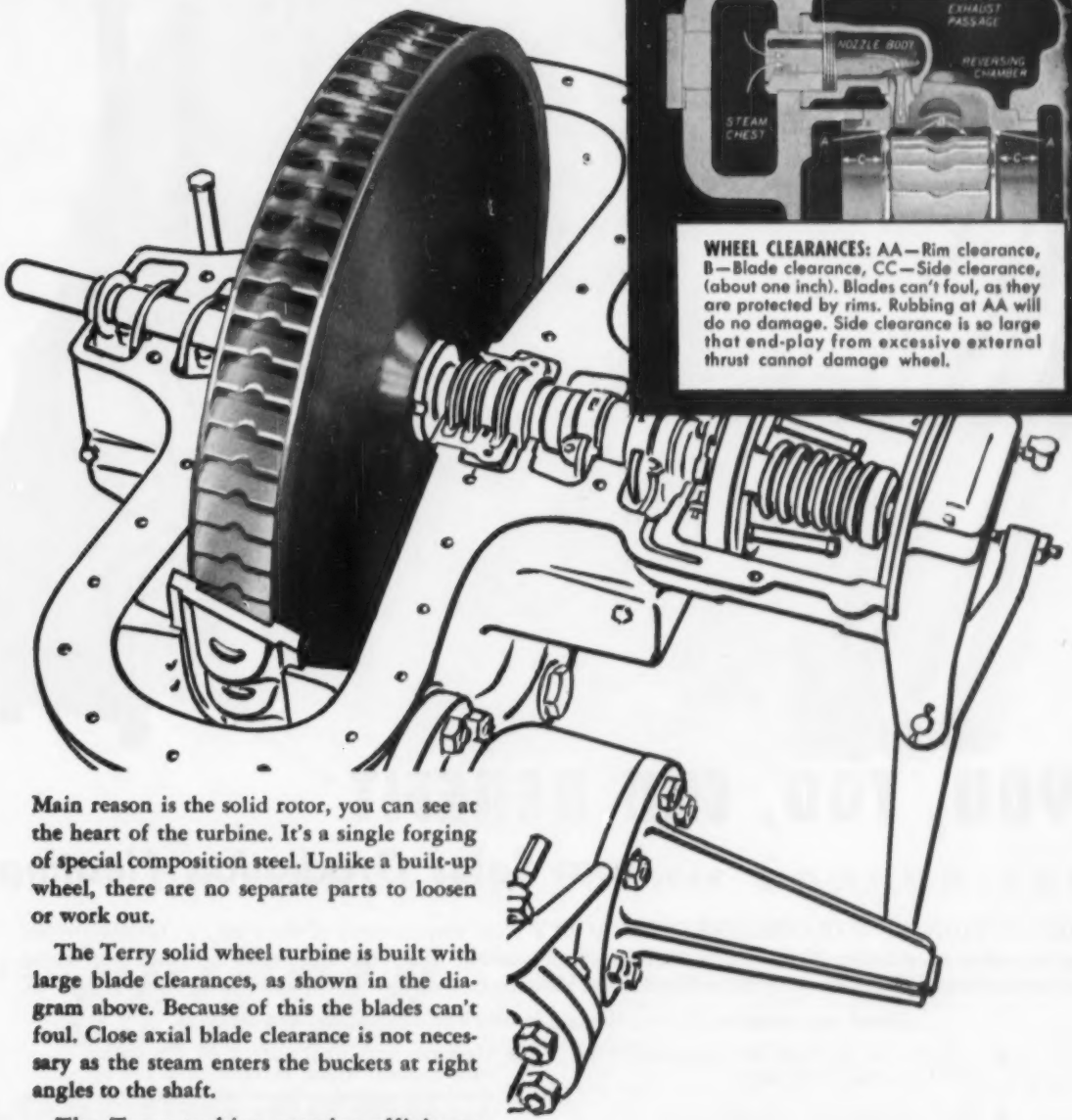
Lubricant Sealed for Positive Shut-off

40th Year
of lubricated plug valve leadership

WHY TROUBLE GOES OUT

when this turbine goes in

WHEEL CLEARANCES: AA—Rim clearance, B—Blade clearance, CC—Side clearance, (about one inch). Blades can't foul, as they are protected by rims. Rubbing at AA will do no damage. Side clearance is so large that end-play from excessive external thrust cannot damage wheel.



Main reason is the solid rotor, you can see at the heart of the turbine. It's a single forging of special composition steel. Unlike a built-up wheel, there are no separate parts to loosen or work out.

The Terry solid wheel turbine is built with large blade clearances, as shown in the diagram above. Because of this the blades can't foul. Close axial blade clearance is not necessary as the steam enters the buckets at right angles to the shaft.

The Terry turbine sustains efficiency through the years. Reason: The power producing action of the steam takes place on the curved surfaces at the back of the buckets, so blade wear which might occur is of little consequence.

Bulletin S-116 tells more about these *"Work Horses of Industry."* Send for a copy today.

THE TERRY STEAM TURBINE COMPANY
TERRY SQUARE, HARTFORD 1, CONN.

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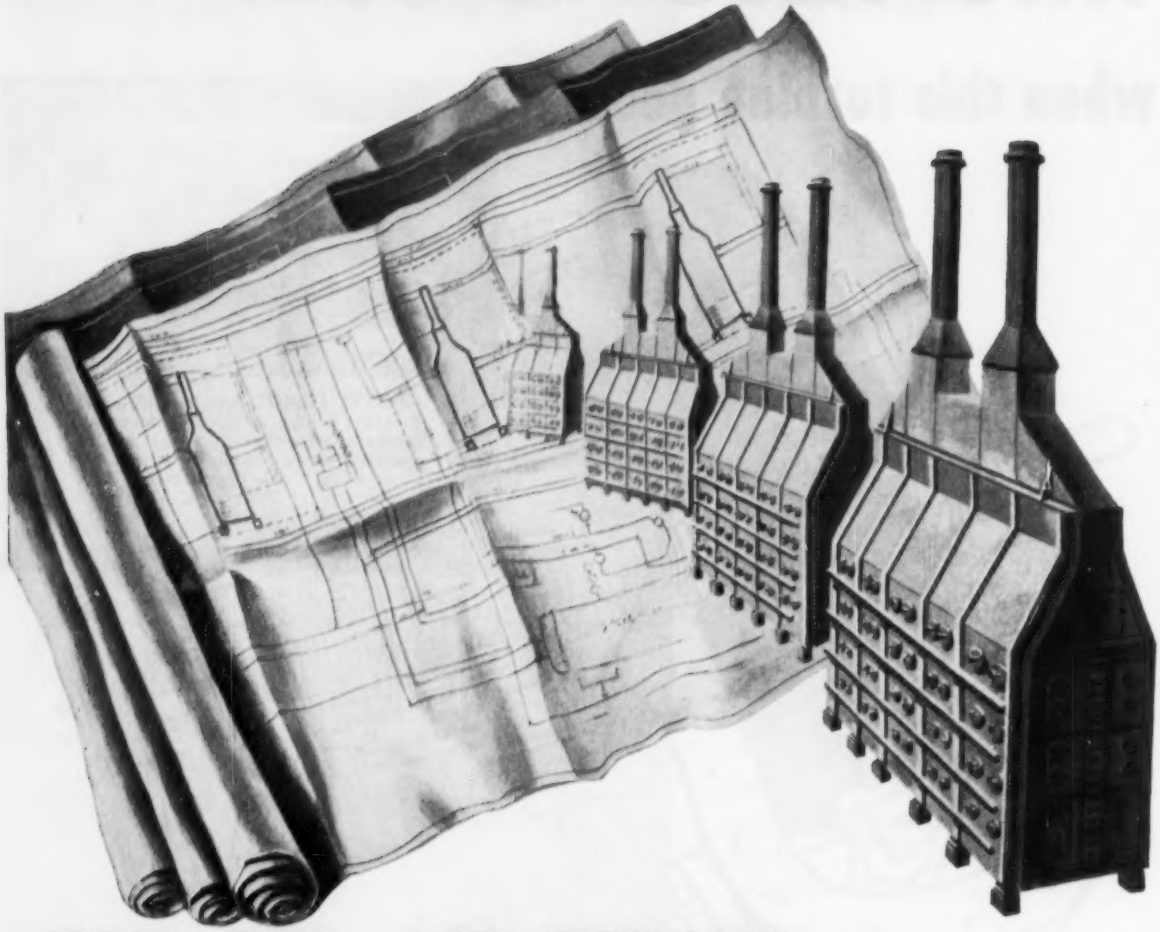

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OPERATION AT THE DESIGNED CAPACITY from the moment of start-up . . . uninterrupted production of ethylene flow . . . versatility in processing different feed stocks . . . are important benefits that will be assured by Selas Gradiation Heating in your new or expanded ethylene operations.

Based on a number of Selas Heaters in ethylene service, you can expect:

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- High conversions and selectivity
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- Optimum conditions even with extreme variations in feed stocks
- Uniform heat distribution on the entire tube surface which extends tube life by eliminating local overheating and material degradation at the tube wall
- Controlled combustion, with little or no excess air to cause external oxidation of the tubes . . . no lag in response to controller demand.

Send for copy of reprint, "Try the Gradiation Heater for Economical Ethylene Production" and Bulletin 86, "Gradiation Heating for Petroleum and Chemical Processing."

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DRESHER, PENNSYLVANIA
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TAKE A TIP FROM

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LOADING ARMS

To maintain smooth production schedules, Eastman Kodak brings corrosive solvents and acids to its Rochester plant via truck from nearby tank farm storage. Corrosive action, however, was destroying loading hoses after comparatively short periods of use. To overcome this costly problem Kodak replaced its hoses with Chiksan Loading Arms. That was 10 years ago. Today, there are over 40 Chiksan Loading Arms in service at Kodak Park and not one record of product fatigue to date.

Whatever your fluid handling requirements, be it corrosive or other, insist on Chiksan Loading Arms—the time proven answer where the accent is on service, safety and speed.

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Well Equipment Mfg. Corp. (Division), Houston 1, Texas • Subsidiaries: Chiksan Export Company • Chiksan of Canada, Ltd.

When the pressure is on

As a final step in the manufacture of Powell Valves, every valve is subjected to an *actual line test*—a *positive method* of testing. For special services, valves can be given hydrostatic, air and gas tests so that they will meet various fluid control services.

Thus, when the pressure is on *you*—when you have a production schedule that must be met—that's when you'll be glad you installed Powell Valves.

No matter what your flow control problem may be, Powell has valves designed to solve your problem. And you can *depend* on long, trouble-free service. Through careful quality control, *every* Powell Valve has PERFORMANCE VERIFIED.

Because of Powell's painstaking quality control, plant shutdown through valve failure is greatly reduced. Records from refineries, power and industrial plants the world over prove it.

Consult your Powell Valve distributor. If none is near you, we'll be pleased to tell you about our *complete quality line* which has *Performance Verified.*

The Wm. Powell Company
Cincinnati 22, Ohio

. . . 110th YEAR

PERFORMANCE
PV
VERIFIED

Bronze, Iron, Steel and Corrosion-Resistant Valves

FIG. 1561—150-Pound Steel Swing Check Valve

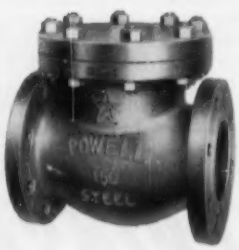


FIG. 1503—150-Pound Steel Gate Valve

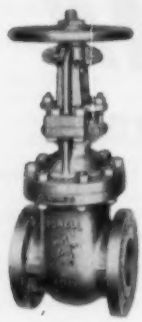
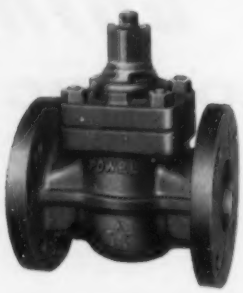


FIG. 2201—175-Pound W.O.G. Semi-Steel Lubricated Plug Valve



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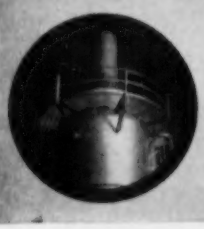

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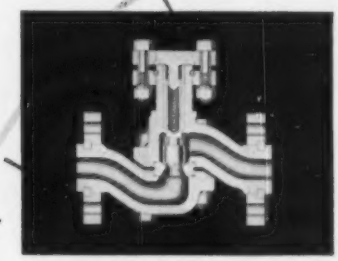
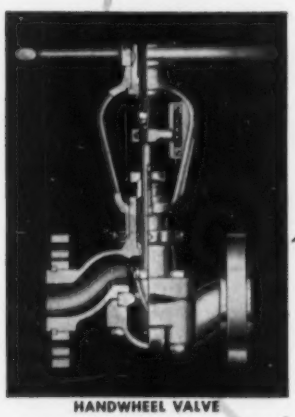


CHECK VALVE



HANDWHEEL VALVE

DOMOTOR VALVE

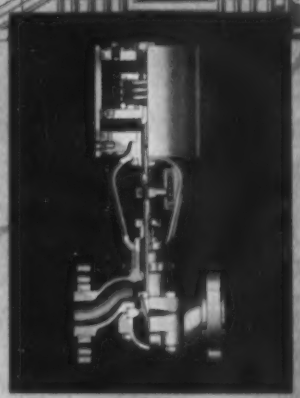


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Photo courtesy Standard Oil Co., (N. J.)

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LJUNGSTROM® AIR PREHEATER

Slag—primary cause of reduced capacity—can be substantially reduced by the Ljungstrom Air Preheater... to keep you on stream *at top capacity* months longer.

That's because preheated air mixes more thoroughly with fuel. The result is better combustion... and less slag-forming material present in the furnace. Oil tubes stay cleaner ...stills stay on stream at top capacity for months longer. As an example, one pipe still in an eastern refinery dropped from 16,000 barrels a day to 12,000 because of slag. Now, with a Ljungstrom and modern high-temperature burners, the still operates continuously at 18,000/20,000 barrels.

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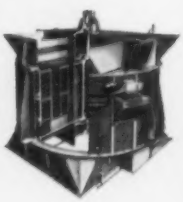
By cutting turnaround time alone, the Ljungstrom means major savings for you. When you take the other Ljungstrom advantages into account—up to 20% fuel saving... more economical furnace design, with no need for convection surfaces... burns many fuels you used to throw away... consistently higher through-put... higher product quality—you can see why a Ljungstrom is paid out in just a few months.

For more complete details on what the Ljungstrom Air Preheater can do for you... for an analysis of the heat recovery benefits attainable in fuel burning equipment—call or write The Air Preheater Corporation.

Wherever You Burn Fuel, You Need Ljungstrom



The Ljungstrom operates on the continuous regenerative counterflow principle. The heat transfer surfaces in the rotor act as heat accumulators. As the rotor revolves, the heat is transferred from the waste gases to the incoming cold air.

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Everywhere from "The 40th" north your plant is certain to need at least partial cold weather protection—the kind of winterizing Stearns-Roger designed and built into this natural gasoline plant. The customer wanted the best personnel and process protection for severe winters with minimum cost for a turn-key job.

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Stearns-Roger engineers are prepared for such assignments anywhere, be it enlargement, modernization, or new facility. For your next Cold Country gasoline plant or refinery project, large or small, arrange now to

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Clad steel will give us the same protection and long equipment life as solid high alloy!

...and at a down-to-earth cost!

Clad steel demonstration unit recently featured at the Nat'l Assoc. of Corrosion Engineers show.

LOOK AT THE RECORD!

SEE FOR YOURSELF!

ECONOMY—high-alloy layer assures corrosion resistance, long equipment life.
STRUCTURAL STABILITY—low-cost backing steel provides strength and rigidity.
DESIGN FREEDOM—integral bond allows design and fabrication of shapes to meet process and space needs.

■ Use of clad steel is growing fast throughout the petroleum and petrochemical industries. You see it wherever corrosion or product contamination are problems—in fractionating towers, desulphurizers and other vital equipment.

Even if you *could* afford solid high alloy, you couldn't buy better, more lasting protection than this. Economical clad steel offers the benefits of solid high alloy—*at a practical price*. The permanent, integral bond between cladding and backing steel simplifies construction—eliminates seepage and crevice corrosion. Extreme heat, cold, and quick temperature changes won't affect it!

Add to this, clad's easy maintenance. Add easy modification—walls can be cut, flanges or pipes welded on quickly and easily, without injuring clad surface or bond!

And only Lukens offers a selection of 16 cladding and 11 backing metals—practically an unlimited selection of cladding and backing combinations to meet any conceivable need.

For more information consult your equipment builders or write to Manager, Marketing Service, Lukens Steel Company, 840 Lukens Building, Coatesville, Pennsylvania.

We'll show you in detail just why we say *clad steel is the ideal material for long range economy.*

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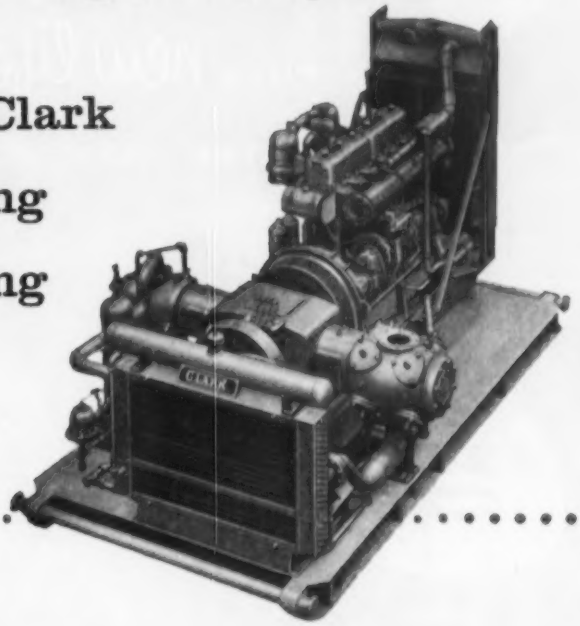
NOW... a compact 75-200 bhp Packaged Compressor

Designed by Clark for gas lifting or gathering



FEATURES

BALANCED/OPPOSED COMPRESSOR DESIGN
Virtually vibrationless . . . a couple of yards of concrete will level it.

DIRECT CONNECTED
Eliminates belts or gear drives.

ONE PIECE SKID
Only 7′ 3″ x 15′, rigid heavy "I" beam construction.

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Lower than on most Clark stationary compressors.

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Straight finned tubes. Easy to inspect or clean, inside or out.

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No field assembly. Shipped as a complete unit.

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Five makes of proved engine designs available.

APPLICATIONS
Use it for gas lifting, gas gathering, gas boosting, pipeline testing, recycle plant feeders, other field services.

You asked for this field compressor—as rugged, compact and perfectly balanced as the famed "Midget Angle" but of half the horsepower.

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The CFA uses a new specially designed 5" stroke Balanced/Opposed compressor directly connected to a standard design gas engine. The compressor and engine, together with radiator, scrubber, etc., are mounted on a rugged steel skid measuring only 7′ 3″ x 15′.

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ONE OF THE DRESSER INDUSTRIES
Offices in Principal Cities Throughout the World

CLARK® **Packaged Compressors**

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See how Hills-McCanna metering pumps can meet your exact requirements.

See how Hills-McCanna design gives you greater dependability, accuracy and longer pump life.

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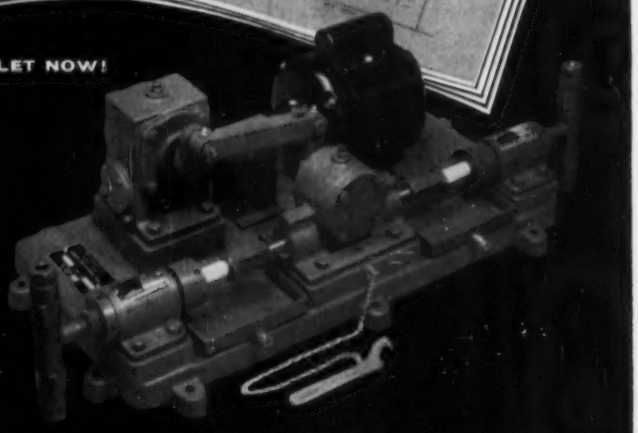

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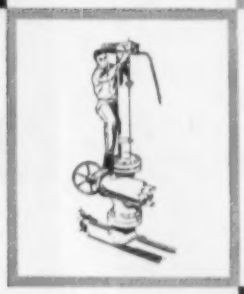

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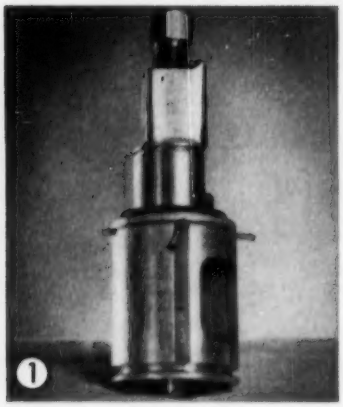
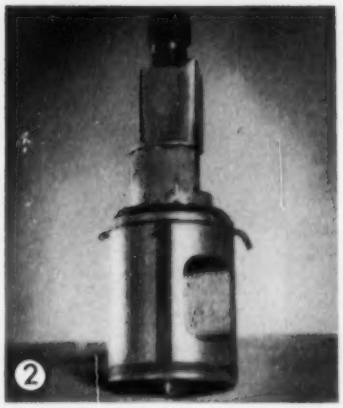
*SEE HOW *Controlled*
PRESSURIZED LUBRICATION
GUARANTEES LOWEST COST SERVICE FROM

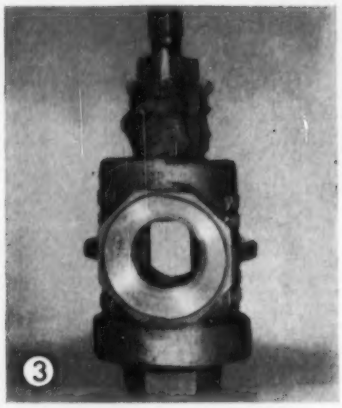
HOMESTEAD *lubricated* PLUG VALVES



This plug was removed from a Homestead Valve just after starting lubrication, and before all sealing areas were filled with lubricant. Note that pressurized lubricant continues to extrude through feeder holes. Momentary downward movement of plug at start of each lubrication, gives assurance that plug is always free to turn.

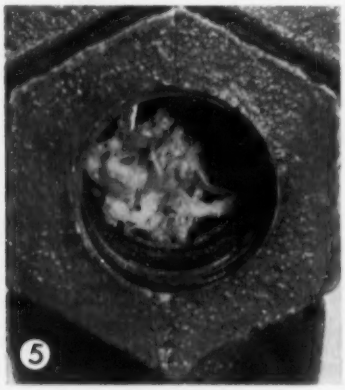


The plug was again withdrawn from the valve body just after a ring of lubricant around the stem indicated that the lubricant system was full. Note that all lubricant grooves are filled. The entire plug surface is coated with lubricant. Lubricant is well packed in the stem sealing area above the plug.



Now valve has been purposely over-lubricated as indicated by excess lubricant around stem. Note that with *controlled* pressurized lubrication there is no extrusion or seepage of lubricant into valve port opening. This means no waste, no contamination of line fluids, no clogging of low pressure lines with lubricant, or fouling of meters, orifices, etc.

Also, in the Homestead Valve with *controlled* lubrication, you will note that even though the valve has been over-lubricated, lubricant comes only to the bottom edge of the plug, and is not wasted by discharging in quantity into the bottom chamber.



Now, see for yourself the risk involved when a valve which does *not* have Homestead's *controlled* Pressurized Lubrication, is over-lubricated. Note lubricant has been forced into the port opening. It can contaminate line fluids, foul meters or orifices, or even block low pressure lines!

* Unretouched photos.

These are but a few of the many advantages of Homestead's controlled pressurized lubrication that guarantee lowest cost valve service.

Reference Book 39-5 has the full story—twenty-eight pages of engineering facts, sizes, types, dimensions, etc. Ask for your copy today. There is no obligation.

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HOMESTEAD VALVE MANUFACTURING COMPANY

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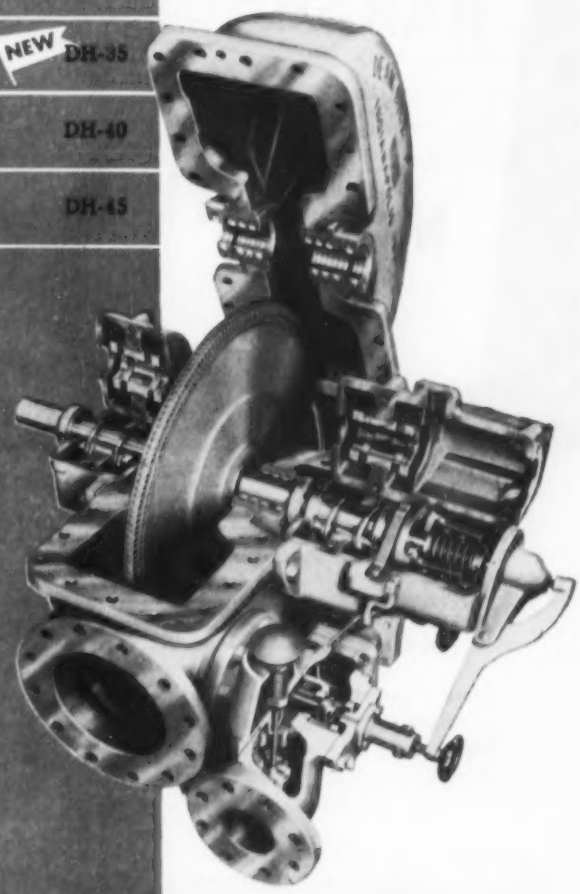
THREE NEW MODELS

DH-10
NEW DH-15
DH-20
NEW DH-25
DH-30
NEW DH-35
DH-40
DH-45

NOW YOU CAN CHOOSE FROM 8 MODELS TO MEET YOUR WORKING REQUIREMENTS



expand DH steam turbine line

The latest in a long series of advancements in the Dean Hill line of horizontal steam turbines is the addition of three new turbines introduced as intermediate models. These new models effect a more gradual increase in power ratings in the horizontal line. The reduced "spread" between ratings in the new 8-model line gives you a better opportunity to match the turbine to the job within a very close margin. Of course, this is always to your advantage in turbine selection.

Because the new models incorporate all the newest improvements made on the other sizes, the Dean Hill horizontal line is one of the most *advanced, complete* lines in the world. With single-stage construction and sleeve bearings, they are specifically designed to operate at medium steam pressures. Low power consumption results in outstanding operational economy of every model in the line.

Write for Catalog No. 500 for details on both vertical and horizontal DH turbines. Information includes cut-a-way illustrations, detailed line drawings, tables, horsepower curves.

DEAN DH HILL PUMP COMPANY

Pump and Turbine Engineers Since 1893
Indianapolis 7, Indiana

Sales Offices In:
Chicago, New York, San Francisco, Boston, Cincinnati, Denver, Albuquerque, El Paso, Salt Lake City, New Orleans, Philadelphia, Tulsa, Los Angeles, Pittsburgh, Houston, Dallas, St. Paul, Toledo, Cleveland, Grand Rapids, Birmingham, Ala., Memphis, Richmond, Mexico City, Montreal, Reading, Pa. The Hague, Washington, Charlotte, Casper, Wyo., Knoxville.

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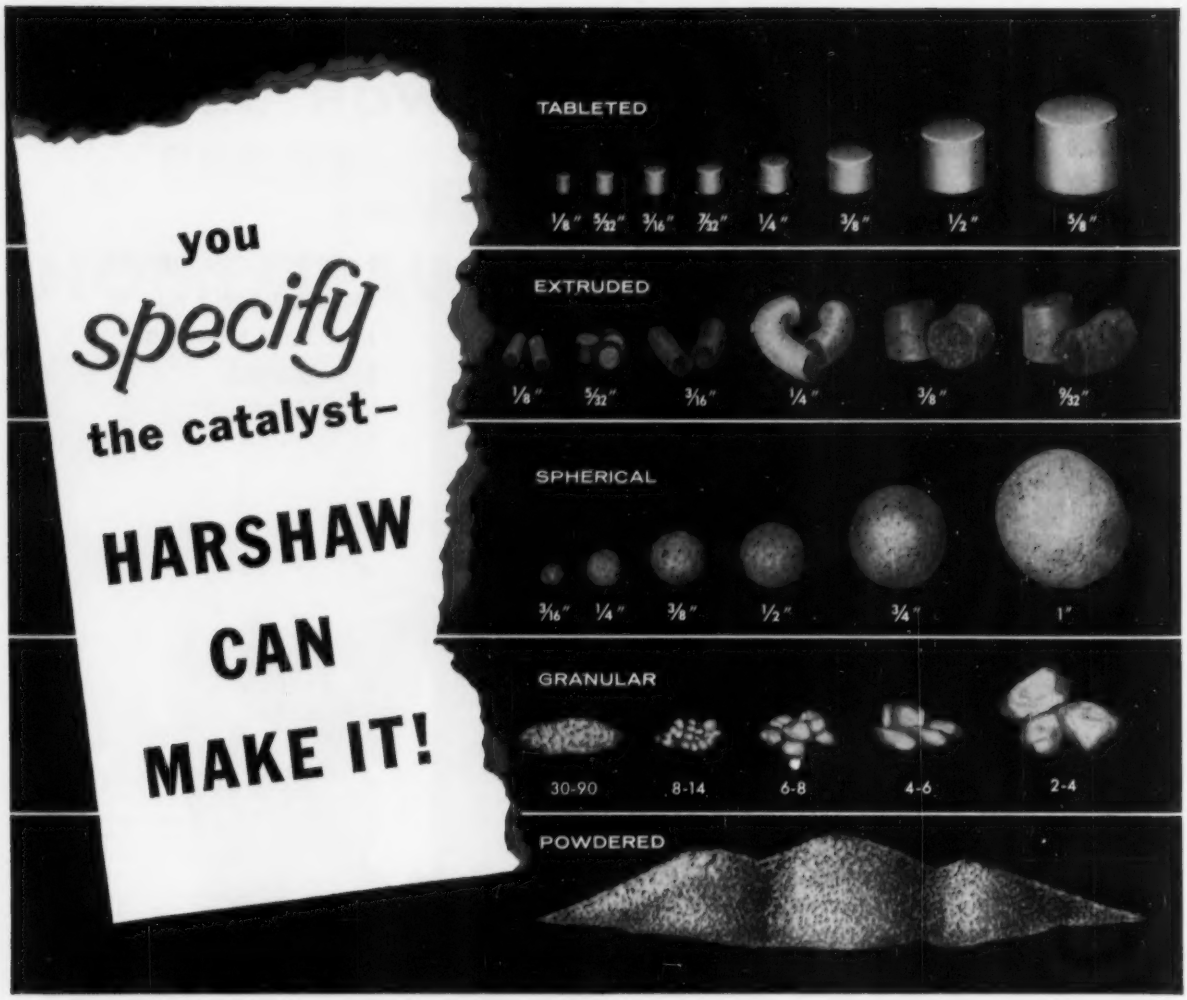

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CATALYTIC CHEMICALS SUPPLIED BY HARSHAW

Aluminum Nitrate — Cobalt Nitrate
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Our experienced technical staff will assist you in developing the best and most economical catalyst. If you have a catalytic process in the development or production stage, a discussion with us may prove beneficial.

Write for FREE Booklet, "HARSHAW CATALYSTS"

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THE HARSHAW CHEMICAL CO.

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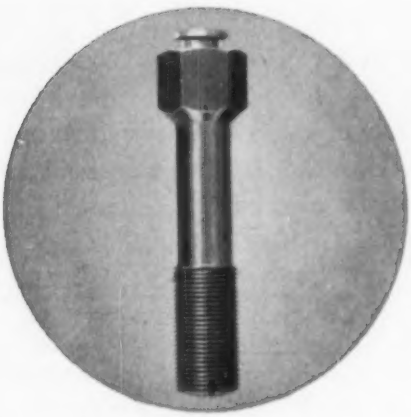
LUBRICATE PLUG VALVES

in seconds— instead of minutes

with this timesaving combination

Yes, seconds are all it takes to lubricate plug valves, today. You'll eliminate waste, and save time and effort with this combination: Walworth High Pressure Lubricant Gun, Walworth Button-Head Fittings, and Walworth Jumbo Size Lubricant Sticks. They'll pay for themselves quickly and are adaptable to most of the lubricated plug valves that are in use today.

Walworth High Pressure Lubricant Gun. This is the only gun available today that satisfactorily handles the stick form, full-bodied lubricants needed for proper lubrication and sealing of plug valves. Easy to operate; two Jumbo Size Lubricant Sticks fill the barrel.



Walworth Button-Head Lubricant Fittings. Use them as lubricant fittings or as regular lubricant screws with standard size lubricant sticks. Just slip hose coupling onto fitting for a leakproof connection.

Walworth Jumbo Size Lubricant Sticks. Individually wrapped and packed ten to the box; clean and easy to handle . . . eliminate messy loading. Types available for most line fluids. Always use Walworth Lubricants in Walworth Lubricated Plug Valves.

Start saving today . . . call your nearby Walworth Distributor. He'll be glad to supply Walworth High Pressure Lubricant Guns, Button-Head Fittings, and the right Jumbo Size Lubricant Sticks for any lubricated plug valve service condition.

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HOW'S THIS FOR OS&D HOSE PERFORMANCE?

Tanker loading conditions are particularly severe at the Union Oil Company's Port San Luis Wharf, Avila, California. When heavy seas are running, tankers must be held some 75' to 100' away from the dock with the aid of four heavy mooring buoys plus the ship's anchor. In spite of these conditions, Hewitt-Robins Smooth Bore Oil Suction & Discharge Hose performs with maximum efficiency.

Normal life expectancy for loading hose at this installation is 15,000,000 barrels, yet a single line of Hewitt-Robins Smooth Bore OS&D Hose has handled over 37,000,000 barrels to date. Here again, a customer's performance record has shown that for longer hose life and more economy in operation the first and best choice is Hewitt-Robins Hose.

For immediate information regarding Hewitt-Robins OS&D Hose or any *Hewitt-Robins industrial hose contact your local Hewitt Rubber Distributor (See "Rubber Products" Classified Phone Book.)*

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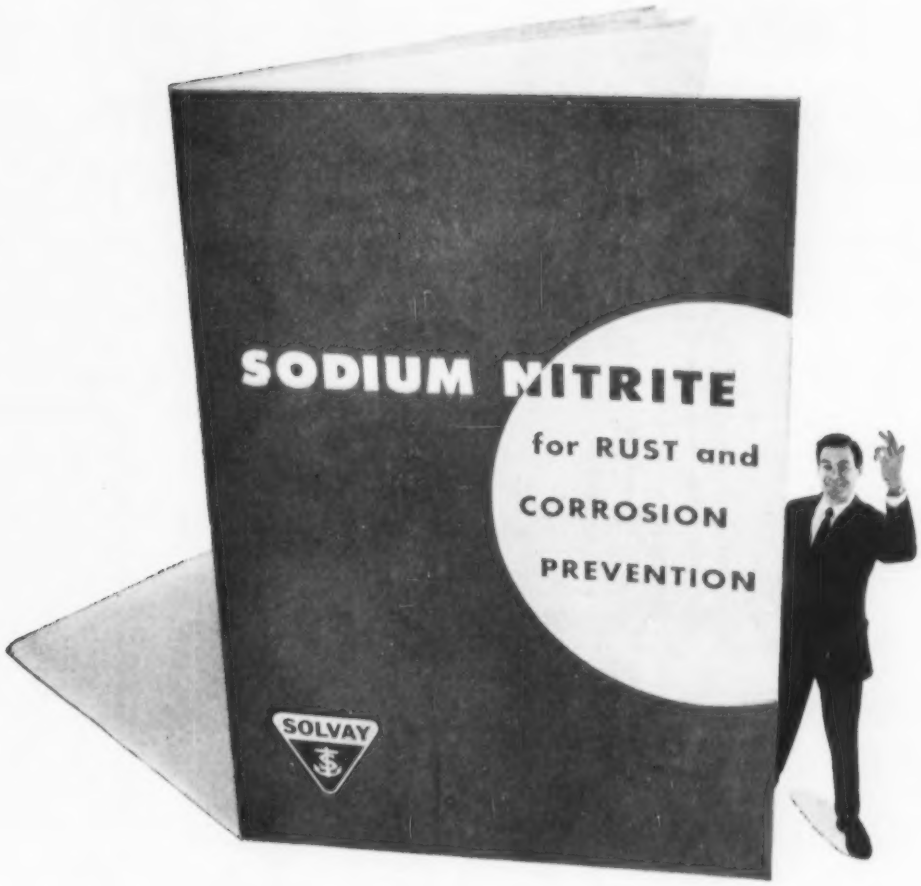
STAMFORD HR CONNECTICUT

INDUSTRIAL HOSE • CONVEYOR BELTING • CONVEYOR MACHINERY • VIBRATING CONVEYORS • VIBRATING SCREENS • DESIGN, MANUFACTURE, ENGINEERING AND ERECTION OF COMPLETE BULK MATERIALS HANDLING SYSTEMS • "JONES" POWER TRANSMISSION EQUIPMENT



Come in and see what SOLVAY SODIUM NITRITE can do!

The new edition of this book may prove extremely helpful to anyone interested in the prevention of rust and corrosion.

This new book describes how SOLVAY Sodium Nitrite is being used, alone and in combination with other materials, for the cleaning, neutralizing and protection of metal in such diverse applications as: cargo holds of ocean-going tankers in light petroleum service; steel scouring pads; machined parts in process; steel forms such as sheets, pipes and wire; metal tanks and containers; and circulating water systems.

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Soda Ash • Snowflake® Crystals • Chlorine
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Available without cost. Simply fill in and mail the coupon.

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SOLVAY PROCESS DIVISION
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Gentlemen: Please send me without cost or obligation*

☐ Your new book "SODIUM NITRITE for Rust and Corrosion Prevention"
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Company _____

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*In Western Hemisphere Countries.

ED-6

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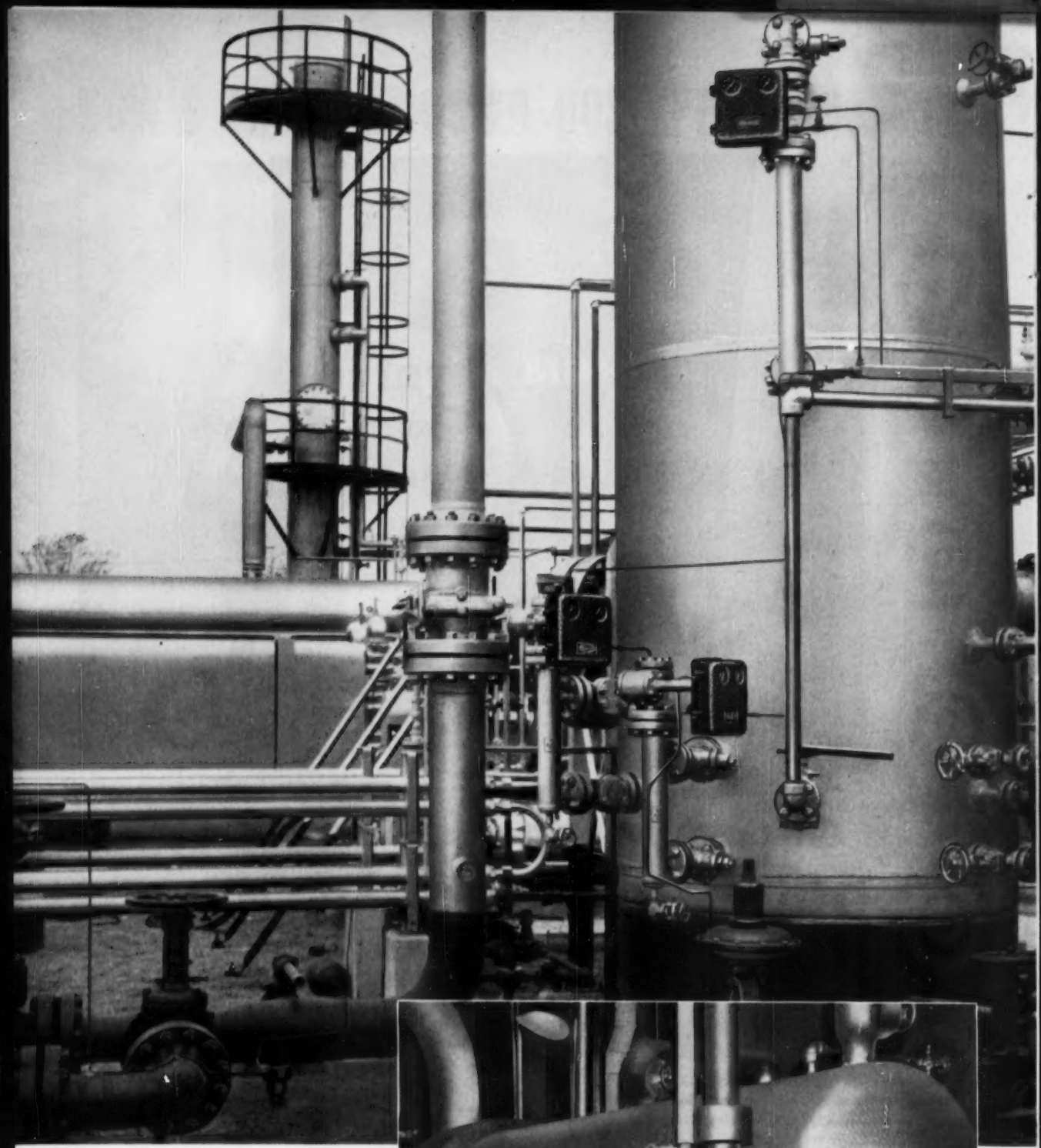
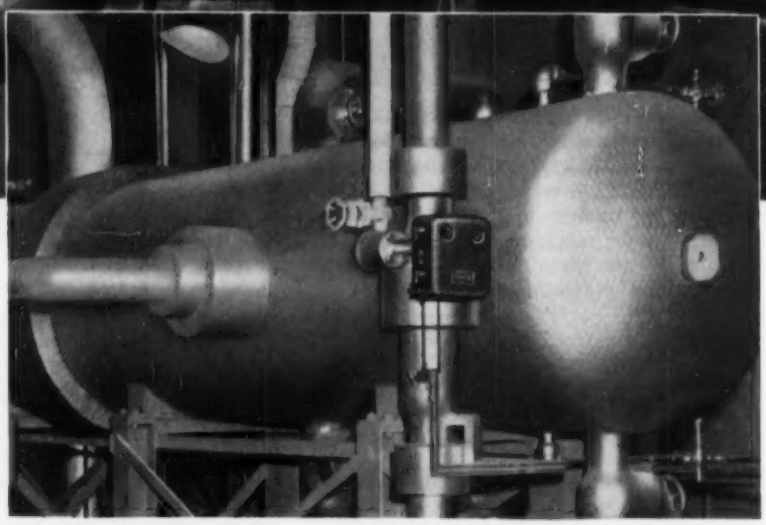


These Masoneilan 12000 Series Liquid Level Controllers are being used for normal and interface level control on a gas dehydration unit.



This is one of the versatile 12000 Series Liquid Level Controllers on a heat exchanger in a power plant installation.

In Masoneilan 12000 Series Liquid Level Controls . . .

Five-Point Versatility Solves Processing and Power Plant Control Problems

Here, in one group of related designs, is a completely versatile and adaptable series of liquid level controllers. They offer a one-source solution to the majority of level control problems with flow and storage of liquids in processing and power plant systems. These range, rating and material specifications, and the flexibility in mountings and control types presented with the photographs below demonstrate this important Mason-Neilan advantage . . .

Wide Selection of Ranges — standard ranges include 14″, 32″, 48″, 60″, 72″, 84″, 96″, 108″ and 120″. Ranges with even longer spans can be supplied.

Wide Selection of Pressure Ratings — In the shorter level ranges, standard ratings are from Class 125 ASA in iron to 2500 lb ASA in carbon steel; in all ranges from 150 lb to 600 lb ASA in carbon steel. Under temperatures up to 100° F steel ratings may go as high as 10,000 lb.

Wide Selection of Materials — to meet all usual conditions, a variety of materials is available:

For displacer chambers — iron, carbon steel, bronze, carbon molybdenum, chrome molybdenum, stainless steel, Monel, etc.

For displacers — Type 304 and Type 316 stainless steel, Monel, Hastelloy B or C, Durimet 20, copper and solid Teflon.

For torque tube subassemblies — Inconel, Type 316 stainless steel, K-Monel, Hastelloy B or C, nickel, phosphor bronze, Durimet 20, etc.

There are Masoneilan 12000 Series models for a multiplicity of applications . . . industry's widest selection of liquid level controllers. Look to Mason-Neilan to answer *your* problem. Write for catalog.

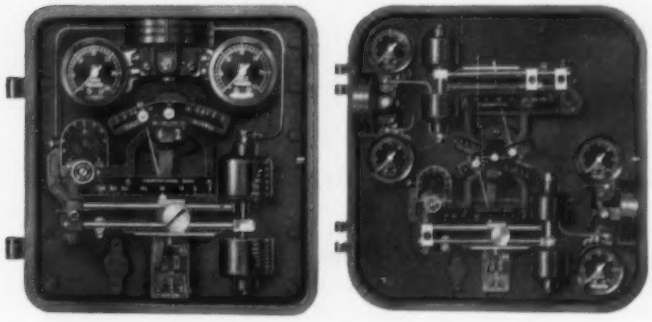
MASONEILAN

MASON-NEILAN

Division of Worthington Corporation

51 NAHATAN STREET, NORWOOD, MASSACHUSETTS

Sales Offices or Distributors in the Following Cities: New York Syracuse • Chicago • St. Louis • Tulsa • Philadelphia • Houston Pittsburgh • Atlanta • Cleveland • Cincinnati • Livonia • San Francisco • Boise • Louisville • Salt Lake City • El Paso Albuquerque • Odessa • Charlotte • Los Angeles • Corpus Christi • Denver • Appleton • Birmingham • New Orleans Dallas • Seattle • Mason-Neilan Regulator Co., Ltd., Montreal and Toronto

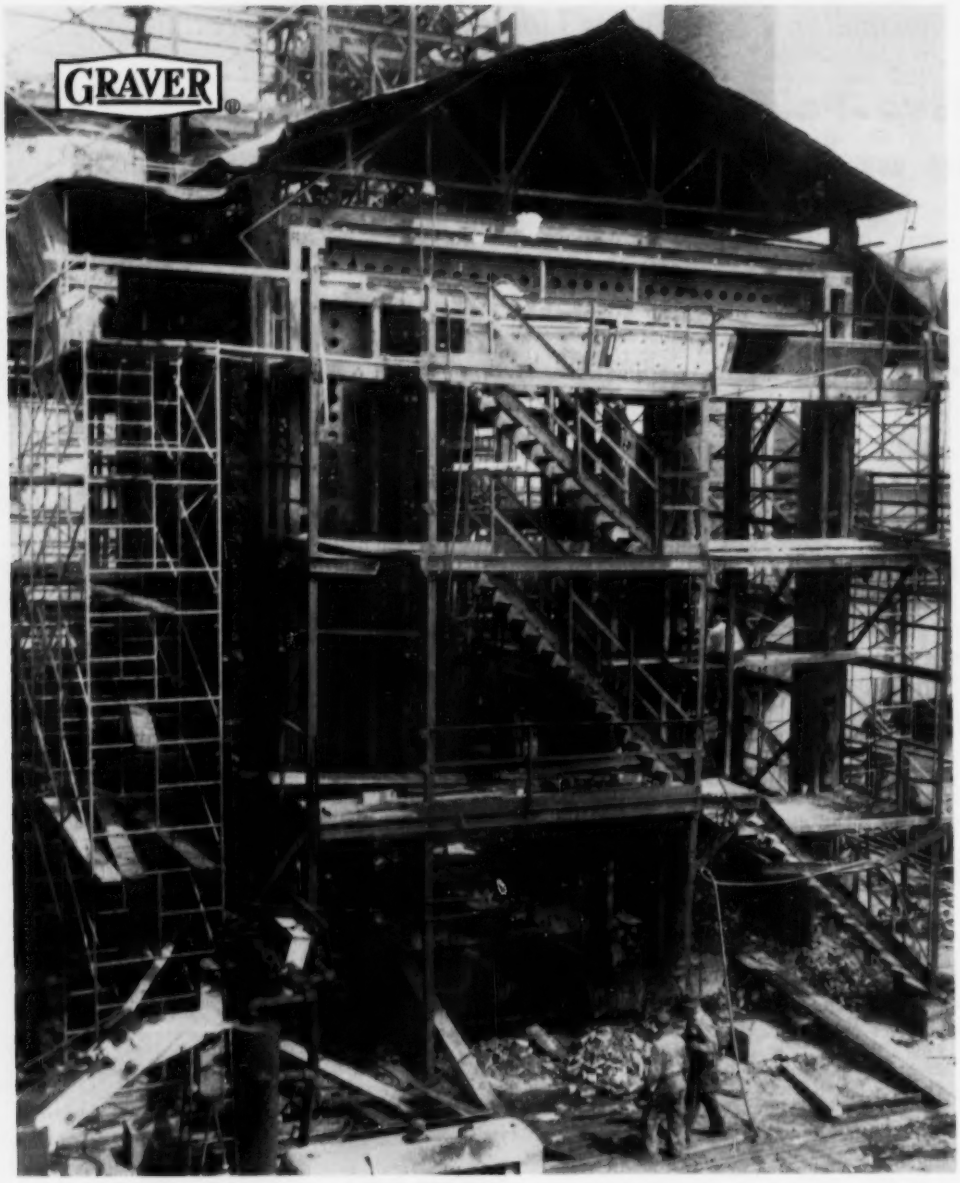


Choice of Control Types

The basic instrument is a proportional controller, left above. In addition, proportional-reset and differential-gap types are available; and pneumatic set may be added for remote pneumatic adjustment of the set-point. Or the instrument may be a pneumatic transmitter instead of a controller. Also, any combination of controllers, or a controller and transmitter, right above, may be included in a single (larger) case and actuated by a common torque tube.

Choice of Mountings

A variety of external mounting types with screwed or flanged connections, plus flanged types for mounting directly on the vessel, provide flexibility in meeting vessel requirements. The instrument may be mounted to right or left of displacer. The chamber types may have a mid-flange for field orientation. Top and bottom flanged connection shown at right.



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...Plant builders for industry

Chem. processing
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There's order in this confusion

Graver is building a pipe still heater for an oil refinery. It is by no means the first Graver pipe still heater, and Graver builds in like proportion such things as complete refineries, chemical plants and steel mills.

Graver experience has been accumulated over 20 years, and as contractor or subcontractor on your big job, Graver will deliver with the right skills and the right equipment.

Other Graver services include setting machinery, mechanical and piping installation, and plant maintenance.

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JEFFERSON

GAS SCRUBBING AGENTS

Monoethanolamine } for sweetening
Diethanolamine } natural and refinery gas

Diethylene Glycol } for dehydrating
Triethylene Glycol } natural gas

You will find that these high-quality chemicals will give you peak performance in your gas scrubbing process. Produced in Jefferson's modern plant in Port Neches, Texas, they are shipped from convenient distribution points at Houston, Port Neches, Chicago, Los Angeles and Tenafly, New Jersey. Immediate delivery is available in tank cars, tank wagons or 55-gallon drums.

For detailed information on gas scrubbing, consult our experienced technical service staff. Call your nearest Jefferson representative for prompt service. **Jefferson Chemical Company, Box 303, Houston 1, Texas.**

Essential Chemicals from Hydrocarbon Sources

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CHEMICAL COMPANY, INC.

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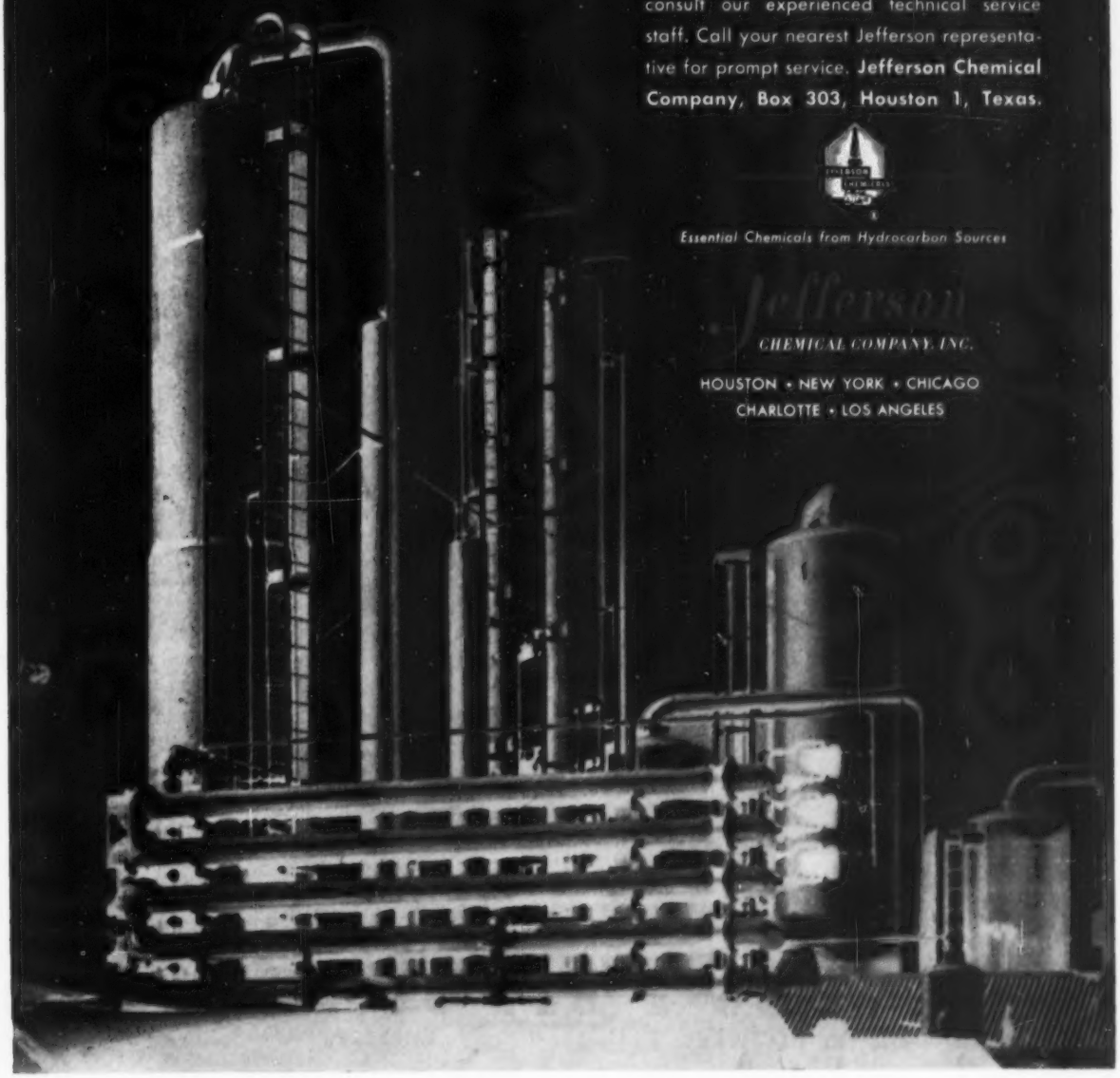
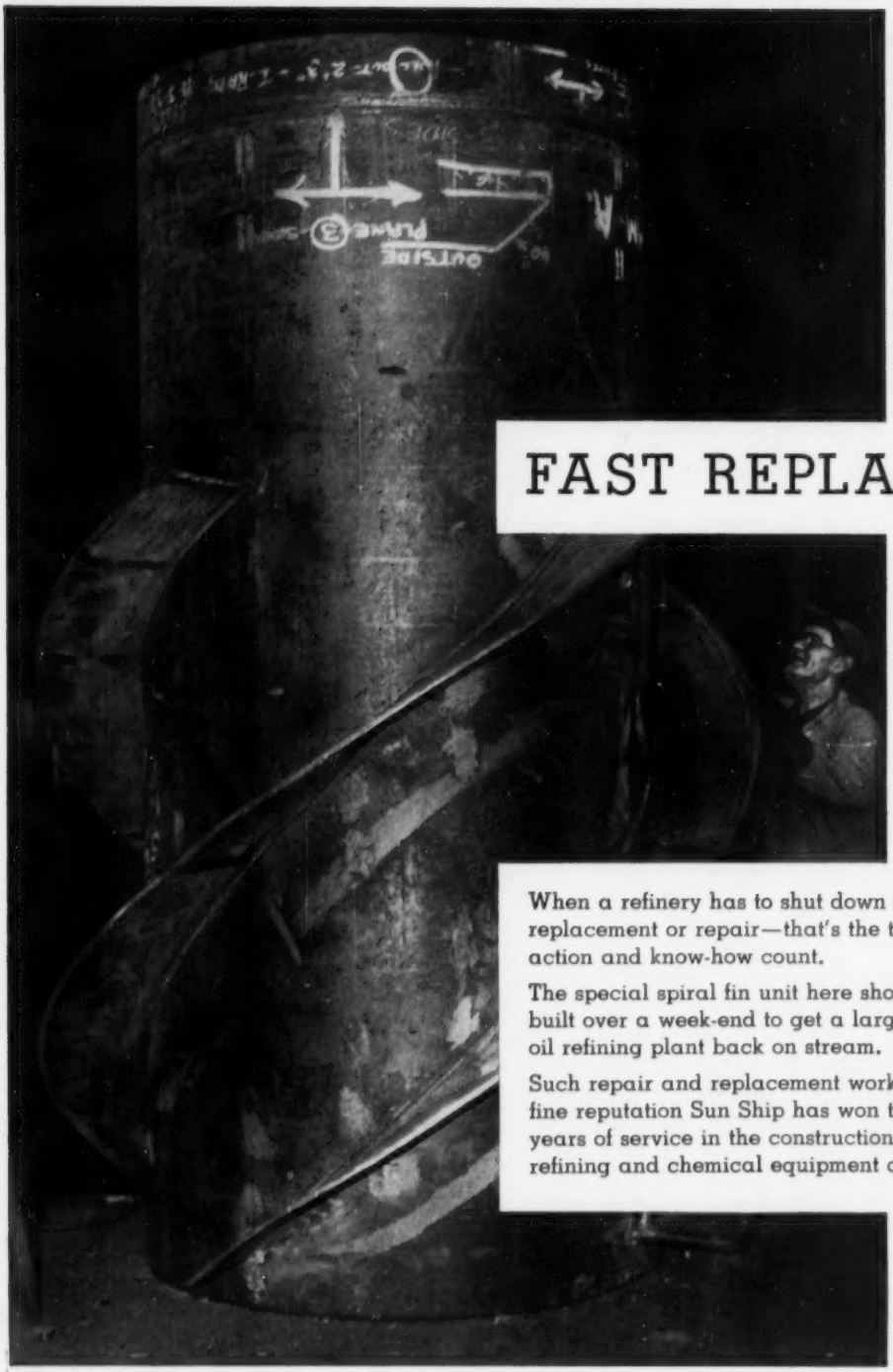


For more data on advertised products, use Readers' Service Cards, last page.



FAST REPLACEMENT

When a refinery has to shut down for a replacement or repair—that's the time when action and know-how count.

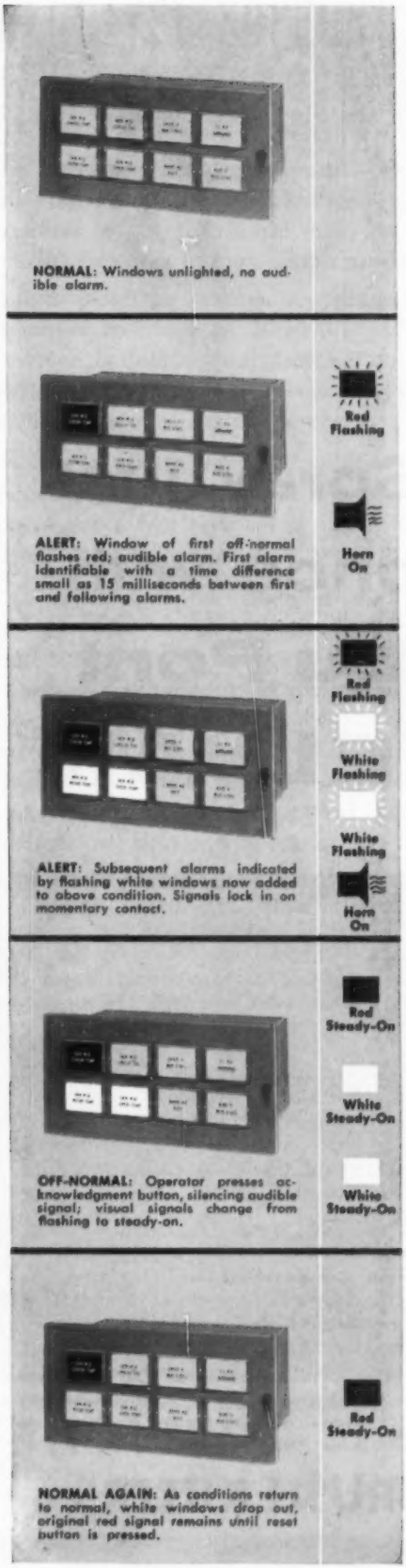
The special spiral fin unit here shown had to be built over a week-end to get a large oil refining plant back on stream.

Such repair and replacement work has added to the fine reputation Sun Ship has won through years of service in the construction of oil refining and chemical equipment of every kind.

Sun

SHIPBUILDING & DRY DOCK COMPANY

ON THE DELAWARE (SINCE 1916) CHESTER, PA.


NORMAL: Windows unlighted, no audible alarm.
Red Flashing
Horn On
ALERT: Window of first off-normal flashes red; audible alarm. First alarm identifiable with a time difference small as 15 milliseconds between first and following alarms.
Red Flashing
White Flashing
White Flashing
Horn On
ALERT: Subsequent alarms indicated by flashing white windows now added to above condition. Signals lock in on momentary contact.
Red Steady-On
White Steady-On
White Steady-On
OFF-NORMAL: Operator presses acknowledgment button, silencing audible signal; visual signals change from flashing to steady-on.
Red Steady-On
NORMAL AGAIN: As conditions return to normal, white windows drop out, original red signal remains until reset button is pressed.

Panalarm "VS" Annunciator identifies first off-normal from subsequent alarms for rapid corrective action

You gain the control advantages of an audio-visual information system, not just an alarm system, with the Panalarm "50VS" Visual Sequence Annunciator. This is particularly valuable when one off-normal condition will cause a "chain-reaction" of off-normals. Typical Panalarm applications are found in the process industries and among users of automatic machinery.

The original off-normal is clearly identified, enabling the operator to take immediate, corrective action. A considerable saving in down-time can often be effected simply by knowing the original source of trouble.

Panalarm "50VS" is completely flexible in setting up various sequential groups. Any number or combination of signals may be grouped as an independent sequence, and the groupings may be changed at any time by simple jumpers on the terminal block. Signals may be either illuminated nameplate or bullseye indicators, combined with a horn, bell or other audible signal. Signaling is simple and positive. A typical sequence is illustrated on the left.

Write for literature on the "50VS" and other Panalarm Annunciator Systems. A Panellit sales engineer will be happy to make a survey of your production operation to determine whether a Panalarm system can help increase efficiency and safety in your plant.

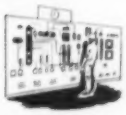
All Panalarm Annunciator Systems are completely modular, permitting future growth and changes. The photographs below illustrate a typical Panalarm Cabinet with illuminated nameplates and the hermetically sealed Panalarm "50" plug-in relay unit. Components throughout are ruggedly built to instrument standards for continuous, dependable duty. Entire Panalarm system is suitable for Class 1, Division 2 installations.

Listed by Underwriters' Laboratories

U.S. Patent No. Re 24,031

Engineered Information Systems for Industry

Panalog Information Systems



Graphic Panels, Control Centers

Instrument Services Division

PANALARM

Division of

PANELLIT, INC.

7415 N. Hamlin Ave.

Skokie, Ill.

Panellit of Canada Ltd. Toronto 14

Still weed-free one year after treatment with "Telvar." The area around the tanks and pipeline was sprayed with a single treatment of "Telvar" a year before this photo was taken. Weed-control costs are cut with "Telvar" because it gives thorough, long-term weed control.

FREE ILLUSTRATED BOOKLETS describe how to control weeds and brush with Du Pont chemicals. Write to Du Pont, Grasselli Chemicals Dept., Rm. D-4032, Wilmington, Del. In Canada, Du Pont Company of Canada Limited, 80 Richmond Street West, Toronto, Canada.

Spray just once with Du Pont TELVAR®

WEED KILLERS

When you use "Telvar" weed killers, vegetation is killed through the roots and regrowth is prevented because the chemical remains in the soil . . . provides residual action all season long. And low dosages (1 to 1½ lbs. per 1,000 sq. ft.) make it cost little for the results you obtain. Such low rates also mean less handling, less use of storage facilities.

"Telvar" weed killers come as wettable powders, are non-corrosive, non-flammable, non-volatile, low in toxicity to humans and livestock.

Include "Telvar" weed killers in your weed-control program this year. Prove to yourself how these products of Du Pont research can help cut your maintenance cost to new low levels.

• • •

Where brush is a problem, Du Pont Ammate® X weed and brush killer is the product you need. It kills more kinds of brush with unusual safety. With ordinary precautions, "Ammate" X may be used close to such crops as cotton, tomatoes, soybeans and peanuts.

On all chemicals, follow label instructions and warnings carefully.

DU PONT
REG. U.S. PAT. OFF.

WEED and BRUSH KILLERS

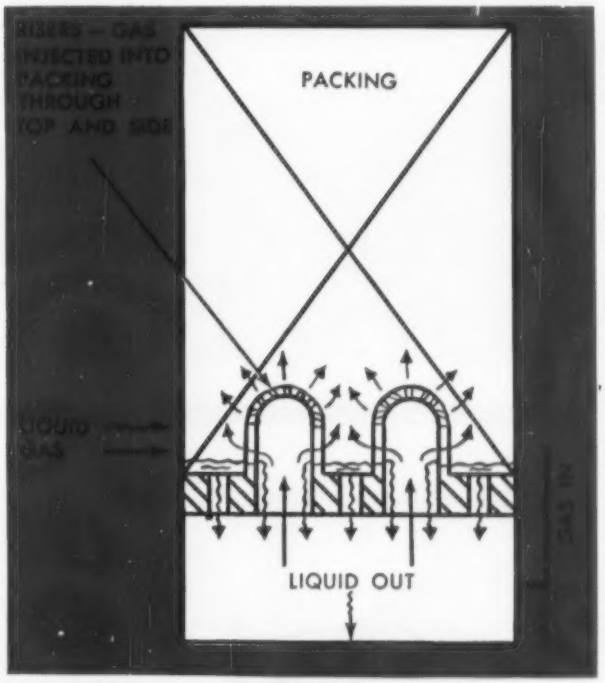
WEIR-TYPE SUPPORT PLATE* IMPROVES PERFORMANCE OF ANY DUMPED TOWER PACKING

The lower pressure drop expected from a high bed voidage can be quickly dissipated by restrictions to gas and liquid flow, set up by a limiting free area in the packing support plates.

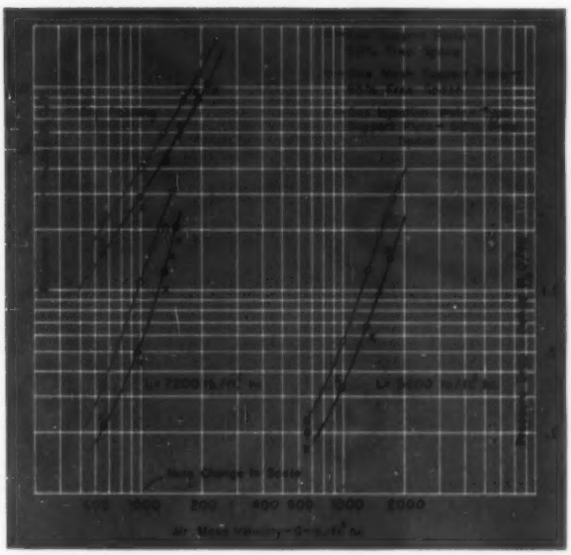
Conventional flat ceramic support plates have an actual free area of 20-30%. *Effective area,* however, is usually much less, because dumped packings, particularly in the smaller sizes, tend to block the openings in the plates.

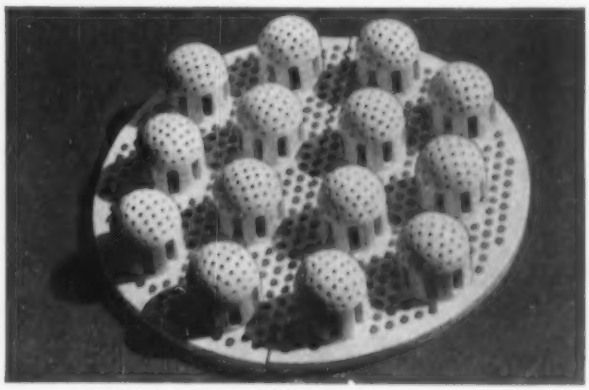
To approximately equal the voidage ordinarily encountered in a packed bed, a support plate must have a free area better than 50%, *under actual operating conditions.*

The weir-type support plate, in every size from 12″ diameter up to 60″ diameter, has better than 50% free area. Its unique, patented design minimizes any tendency of the packing to block the plate openings. Its high mechanical strength provides ample support, and, of course, its chemical porcelain body is completely acid-and-corrosion-resistant throughout (except for hydrofluoric acid and hot caustics).



In operation, the gas is actually injected or distributed into the column through the perforated hemispherical caps and through the upper portion of the slots in the risers. A major portion of the liquid ordinarily leaves the column through the openings in the base plate, but should these openings prove insufficient, and a slight head form, the overflow will escape through the bottom half of the slots in the risers.





Write for New Bulletin— on Weir-Type Support Plates

* U. S. Stoneware patent pending

THE UNITED STATES STONEWARE CO.

Process Equipment Division **AKRON 9, OHIO**

NEW YORK **CHICAGO** **HOUSTON**

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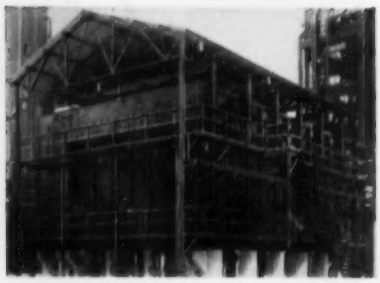
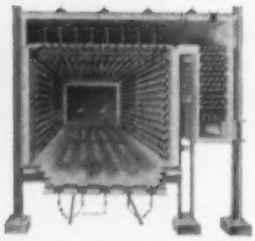
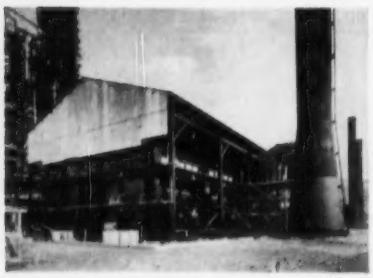
LUMMUS

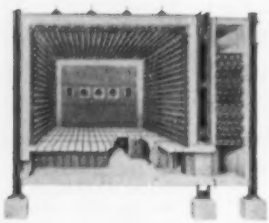
OIL HEATER DIVISION
385 Madison Avenue, New York 17, N. Y.



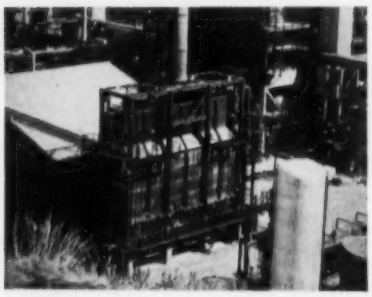


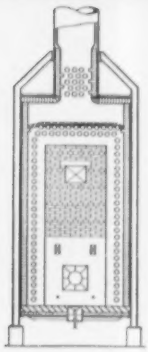
Lummus Standard Oil Heaters are made in two basic types. The up-take heater, illustrated at the left, conducts the products of combustion upward from the entire heating chamber at low and uniform levels of velocity.





The down-take heater, illustrated at the left, is suitable for service where products of combustion would contain corrosive elements or solid matter. It draws hot gases downward from the combustion chamber through the diffusion baffles. Both types of Lummus Standard Heaters are adaptable for multi-coil or multi-stage heating.





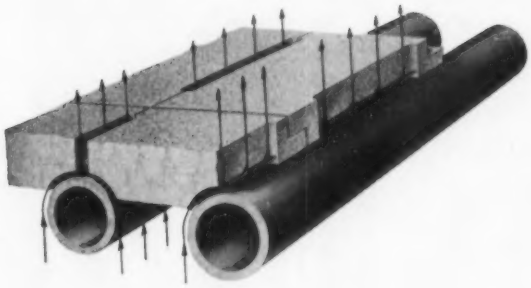
The Economy Heater, illustrated at the left, finds wide application in smaller refineries where the investment necessary for extensive maintenance platforms and roofing is not justified. The flexibility and variety of capacities available with multi-coil and multi-stage settings can be obtained with Lummus-Built Heaters in the same manner as with the larger Standard units.

Lummus Standard Oil Heaters and Lummus-Built Heaters are the answer to the vital problem of supplying process heat in any required amount for petroleum refineries, chemical and petro-chemical plants. Single Lummus Heaters are operating at continuous heat absorptions ranging from 100,000 to 300,000,000 BTU per hour. Lummus has designed and installed heaters for use with every major process.

BRANCH OFFICES — Houston: 2707 Weslayan Rd., Houston 6, Texas • England: The Lummus Co., Ltd., 80 Regent St., London W1, England • France: Societe Francaise des Techniques Lummus, 39 Rue Cambon, Paris ler, France

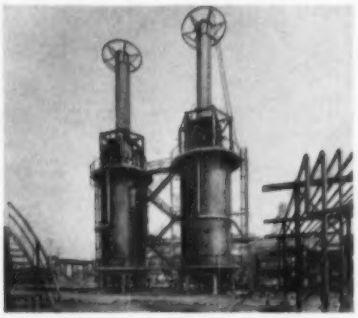
LUMMUS

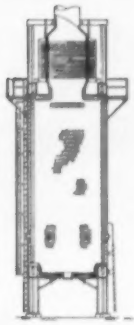
OIL HEATER DIVISION
385 Madison Avenue, New York 17, N. Y.



The patented gas diffusion baffle arrangement shown at the left is characteristic of Lummus furnaces. This arrangement creates a draft resistance or dampering effect which assures uniform evacuation of the products of combustion over the entire ceiling area of the combustion chamber.

Benefits obtained by the use of the slotted refractory baffle tile include high velocity gas flow over the shielded upper row of roof tubes—with consequent high convection heat pick-up—and re-radiated heat from the under side of the tile to the upper side of the bottom row of roof tubes.





Lummus-Built Heaters incorporate the same material, mechanical and operating advantages of the Lummus Standard Oil Heaters but are built along the more simplified and economical lines possible with their smaller size. The Lummus Vertical Tube Heater, illustrated at the left, for milder heat requirements, is especially designed for limited space installation.

The portable heater, left, was built for Magnolia in record time—a mere six weeks downtime compared with the usual five months. It is the height of flexibility and is a smooth-running 100,000,000 BTU per hour heater handling 36,000 B/D of charge stocks—an increase of several thousand barrels over the heater it replaced.

The heaters described above are, of course, Lummus designed. Lummus also has built and will build for you, if requested, counter-parts of all popular types of furnaces used in the petroleum, chemical and petro-chemical industries. Lummus can also build to your specifications any type of specialty heater that a particular production problem calls for. Lummus' 50 years of experience in constructing petroleum and chemical plants lies behind the work of the Oil Heater Division, providing the knowledge necessary to do any job requested by a customer—and to do it right.

BRANCH OFFICES — Chicago: 600 South Michigan Ave., Chicago 5, Illinois • Venezuela: Compania Anonima Venezolana Lummus, Edificio "Las Grandillas", Esquina Las Gradillas, Caracas, Venezuela • Canada: 455 Craig St. West, Montreal

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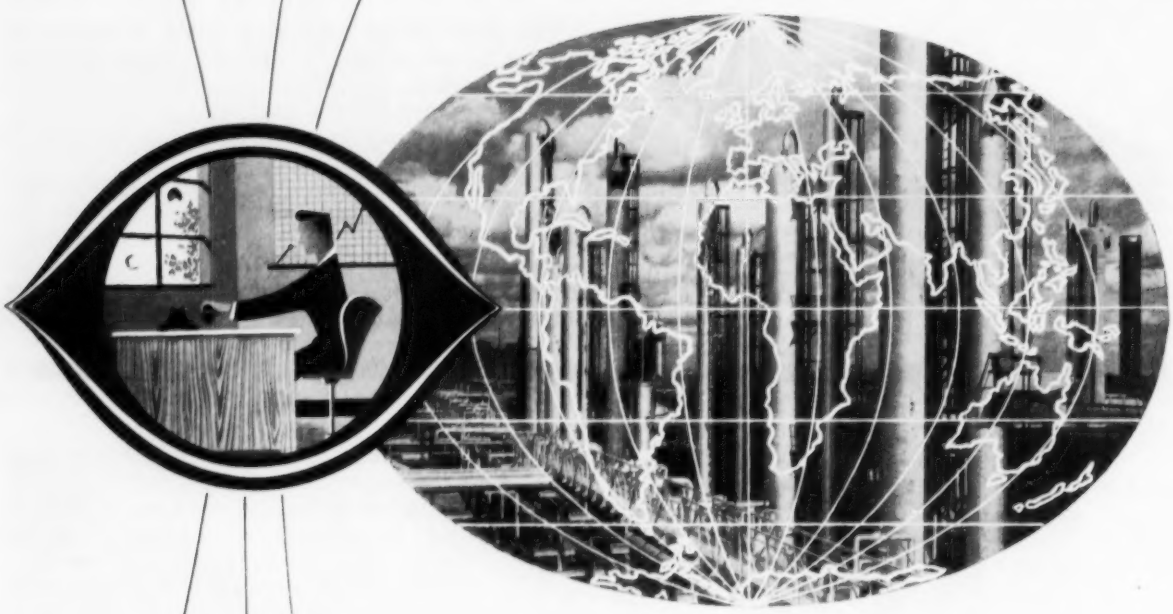
Newalls

OFFERS TECHNICAL SERVICE ON SITE



OIL REFINERIES for which Newalls have supplied insulation materials include the following:

BELGIUM
- * Petrofina, Antwerp
- * Esso Antwerp
- * Albatros Antwerp

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- * Cubatao

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- Port Jerome
- Du Nord (Dunkirk)
- Gonfreville
- Petite Couronne
- Berre

INDIA
- * Stanvac, Bombay

MIDDLE EAST
- * Aden
- Ras Tanura
- Bahrain

VENEZUELA
- Cardon
- * Amuay

* Insulated wholly with Newalls Insulation Company Limited's materials.

NEWALLS ARE CONSTANTLY solving insulation problems all over the world. From Antwerp to Adelaide, Newalls insulation materials are meeting every requirement in Heat, Cold and Sound Insulation. But Newalls service offers more than the supply of materials.

Newalls can also provide supervisory service to smooth out application difficulties on site. Newalls technical staff can handle the specifications and estimating work for any kind of plant, large or small. Calling in Newalls Technical Advisory service is the quickest way to insulation efficiency.

Newalls

TECHNICAL ADVISORY SERVICE

NEWALLS INSULATION CO. LTD.,
Head Office: WASHINGTON, CO. DURHAM ENGLAND
A member of the TURNER & NEWALL ORGANISATION
Agents and Vendors in most markets abroad.

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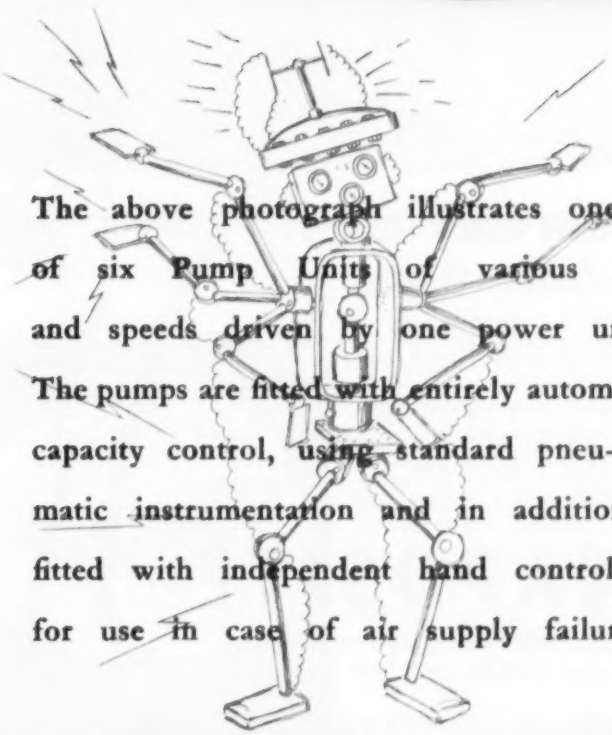
Automation comes to the Refinery



The above photograph illustrates one of four assemblies of six Pump Units of various capacities and speeds driven by one power unit. The pumps are fitted with entirely automatic capacity control, using standard pneumatic instrumentation and in addition are fitted with independent hand control for use in case of air supply failure.

E.C.D LTD
TONBRIDGE · KENT

E.C.D. LIMITED · ENGINEERS · TONBRIDGE · KENT · ENGLAND

Telephone TONbridge 2237 (3 lines) Telegrams TONMIL, TONBRIDGE

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how many humps?

Rough handling by camel, llama, truck or ship . . . who can tell what forms of transport will carry CAPOSITE. These insulating blocks and sections are tough: made of resilient, long-fibred Amosite asbestos for maximum thermal efficiency and maximum strength. CAPOSITE takes the manhandling and knocks of transportation without breaking up.

CAPOSITE

asbestos thermal insulation

—BLOCKS and PIPE SECTIONS

THE CAPE ASBESTOS CO. LTD
114 - 116 PARK STREET • LONDON • W 1
Telephone: GROsvenor 6022

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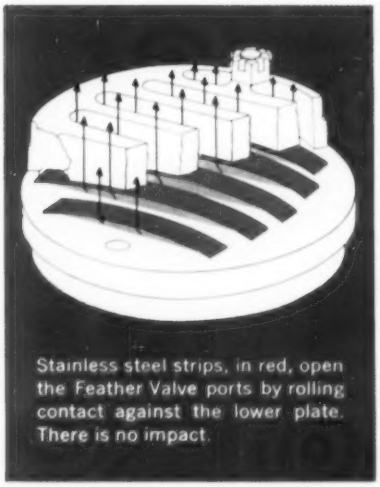
Cape Asbestos (Canada) Ltd., 200 Bloor Street, East, Toronto, Ontario
United States Enquiries: **North American Asbestos Corp., Board of Trade Bldg., Chicago 4, Ill.**

This compressor valve works with no impact for longer life, best efficiency



Stainless steel strips, in red, open the Feather Valve ports by rolling contact against the lower plate. There is no impact.

The Feather* Valve is the lightest, simplest, quietest compressor valve ever developed. Flexible strips of stainless steel open and close the valve ports with a gentle rolling contact. There is no destructive impact . . . even when the valve is operating as fast as forty times a second.

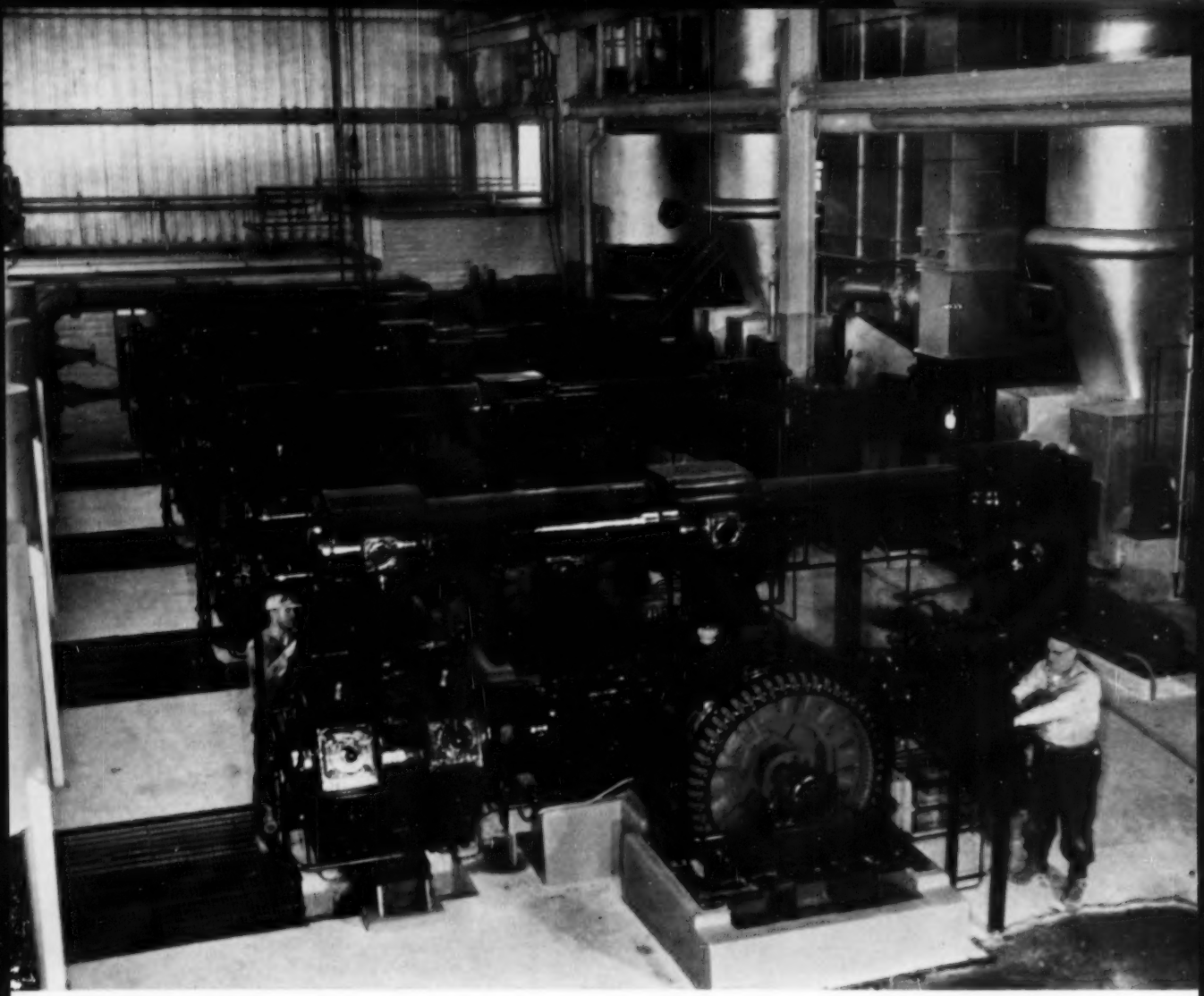
This lack of impact assures long life and negligible maintenance. The valve itself is all but indestructible. Absence of buffer plates and cushioning devices give it extreme simplicity.

The Feather Valve is quiet and reliable because of its lightness and tight contact seating. Valve action is very sharp. There is virtually no slip or back flow. As a result, you get minimum valve loss and use minimum power.

To get the utmost in performance, be sure you specify Worthington when you buy your next compressor. Worthington Corporation, Harrison, N. J. K-6-2

WORTHINGTON

Reg. U. S. Pat. Off.



You get permanent alignment with these balanced opposed compressors

To assure permanent alignment, mated steel tie bars—machined for precise fit—are locked over each main bearing.

Here's the big difference in opposed compressor design—a Worthington exclusive that gives you permanent frame alignment . . . for longer wearing parts life, less maintenance.

Locked in place over each main bearing is a heavy steel tie bar. This makes the frame strongest at the point of greatest loading, assuring years of heavy duty, continuous operation. When necessary, the tie bars are easy to remove for inspection or maintenance.

Other advantages. The Worthington balanced opposed design is more compact, cutting the amount of foundation and floor space needed and saving installation time and expense. It's highly suited to large horsepower multi-service or multi-stage applications. Up to four cylinder pairs can be arranged on one frame.

For more information, see your nearest Worthington District Office or write to Section K63, Worthington Corporation, Harrison, N. J. K-63

WORTHINGTON

Get Ready for Your BIGGEST DATE!

It's coming soon! Your biggest and possibly most important date in 1956—*Oil Progress Week!* It's your chance to make friends for yourself—your business—and your industry.

Each year one week is set aside to bring the oil industry's story directly to the American public. And today more than ever the American people need to know more about your industry—and this is your chance to tell them. Remember, those who know you best like you best.

Here's what you can do

Contact the Oil Industry Information Committee Chairman in your area. He will help you work out an effective program. Participating in Oil Progress Week activities will be good for you and good for your business.

But *now* is the time to plan—*before you go on vacation.* October 14th is nearer than you think and, as you know, it takes time to contact people and organize activities. So clip out the coupon at the right and mail it today!

You Know Your Job—Know Your Industry

Oil Industry Information Committee
50 West 50th Street
New York 20, N. Y.

Gentlemen:

I would like to help tell the story of oil—my story—to the people of my community. Please send me your free booklet explaining Oil Progress Week activities and listing materials that will be available to me.

NAME_____

ADDRESS_____

CITY_____ STATE_____

For more data on advertised products, use Readers' Service Cards, last page.

✔ **Stop entrainment losses**
✔ **Improve product quality**
✔ **Cut process costs**

with METEX Hi-Thruput MIST ELIMINATORS

Collection and recovery of valuable liquid products — removal of liquid particles harmful to subsequent processes — reduced equipment maintenance and decreased air pollution . . . these are but a few of the possibilities METEX Hi-Thruput Mist Eliminators offer to alert process and project engineers.

METEX Hi-Thruput Mist Eliminators, installed in a process tower or vessel, effect sharp separation of entrained liquids within a wide range of vapor velocities. Pressure drop is negligible. Quality and yield are increased. High removal efficiency is maintained, even at extreme temperatures, due to free-drainage of impinged liquids. Liquid slugs cannot enter turbines or compressors. Coke formation is minimized and life expectancy is substantially increased even under adverse conditions.

Where solids may be formed in the mesh because of decomposition, polymerization, crystallization or freezing, METEX Hi-Thruput Mist Eliminators provide up to three times the service life of conventional units.

In any processing equipment or vessel where liquid entrainment is a contributing factor in design or operation, METEX Hi-Thruput Mist Eliminators assure higher production, better processing and lower operating and maintenance costs.

For complete information and specifications, write today for your copy of Bulletin ME-106, illustrating and describing METEX Mist Eliminators for all process equipment.

METEX QUALITY PRODUCTS

6-075

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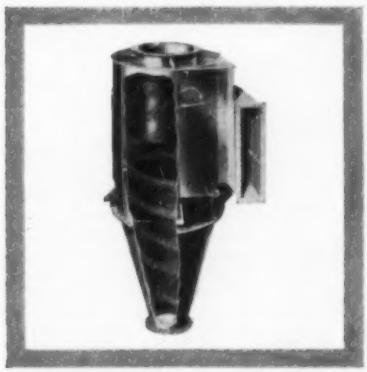
Representatives in principal cities throughout the world

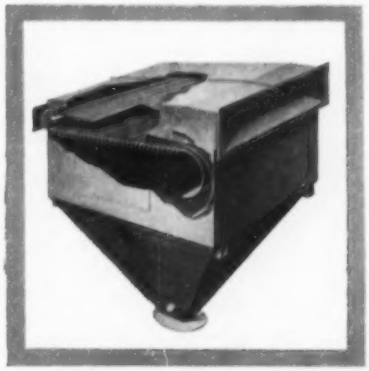
How Buell's Exclusive Rapping Mechanism delivers Extra Dust Collection Efficiency

ORDINARY RAPPING
Shakes dust from collecting electrodes. Re-entrainment of cloud of dust reduces precipitator efficiency
BUELL RAPPING
Shears dust from collecting electrode surface, minimizes scattering and re-entrainment



Buell Cyclones offer two "extra-efficiency" advantages: (1) exclusive Shave-off which harnesses double-eddy and puts it to work, and (2), large diameter design which eliminates clogging.

Complementing the extra efficiency of rapping in Buell "SF" Electric Precipitators, the unique Spiralectrodes add further efficiency through 50% to 100% higher electron emission, constantly accurate spacing, longer electrode life.



Buell's Low Resistance Fly Ash Collector combines top efficiency with low draft loss, for natural or forced draft installations. Ideal for boilers from 100 to 2000 BHP.

For more specific data about Buell's *extra efficiency*, write Dept. 50-E, Buell Engineering Company, 70 Pine Street, New York 5, N. Y.

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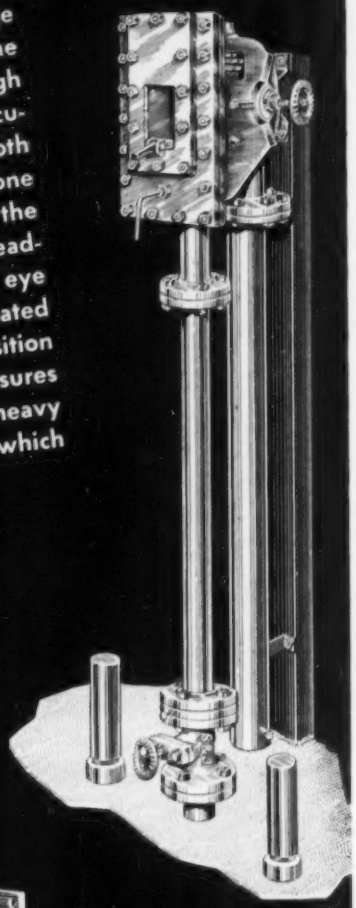
MECHANICAL ELECTRICAL

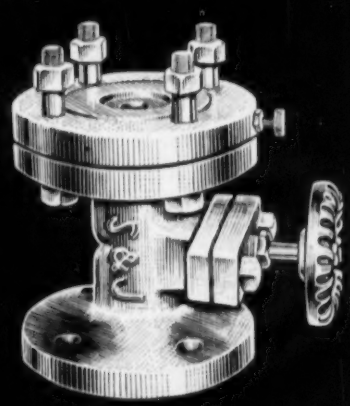
Experts at delivering Extra Efficiency in **DUST COLLECTION SYSTEMS**

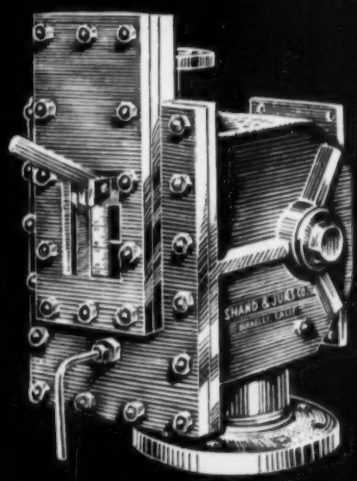
S&J AUTOMATIC GAGES
for Pressure Storage

Since hand gaging of pressure storage vessels is impossible and gage glasses are frequently too inaccurate, automatic tank gaging is the only practical alternative. S. & J. engineers have designed two high pressure automatic tank gages which will consistently and accurately measure product depths in pressure storage vessels. Both gages are similar in operating principle but differ primarily in one important aspect—MOUNTING. Model ST-400 R, illustrated at the right, is designed for mounting on tank tops and for eye level reading. Model ST-400 is designed for ground level installation and eye level reading. In both gages, an 18-8 stainless steel tape, graduated to eighth inches, is affixed to a pressure type float, held in position by guide wires. Both types are available for operation at pressures up to 300 pounds. In both designs, the tape is read through heavy safety glass, which can be kept clear by an inside wiper, and which is protected against breaking by a special steel closure.



The S. & J. Tape Block Valve, Figure ST-5265, passes the reading tape through a heavy synthetic rubber tube. When it is desirable to isolate the gage head from tank pressure, the valve is screwed down to flatten the tube against the tape and provide complete isolation for inspection, maintenance or repair of the reading head.





S. & J. Automatic Tank Gages are available in a great variety of designs, from the most simple, to elaborate electric telepulse remote reading gages. Having pioneered automatic tank gaging, you can look to S. & J. to supply a SAFE and ACCURATE automatic tank gage for every requirement in the petroleum industry. Tell us of your requirements and we will gladly make recommendations covering any gaging problem.

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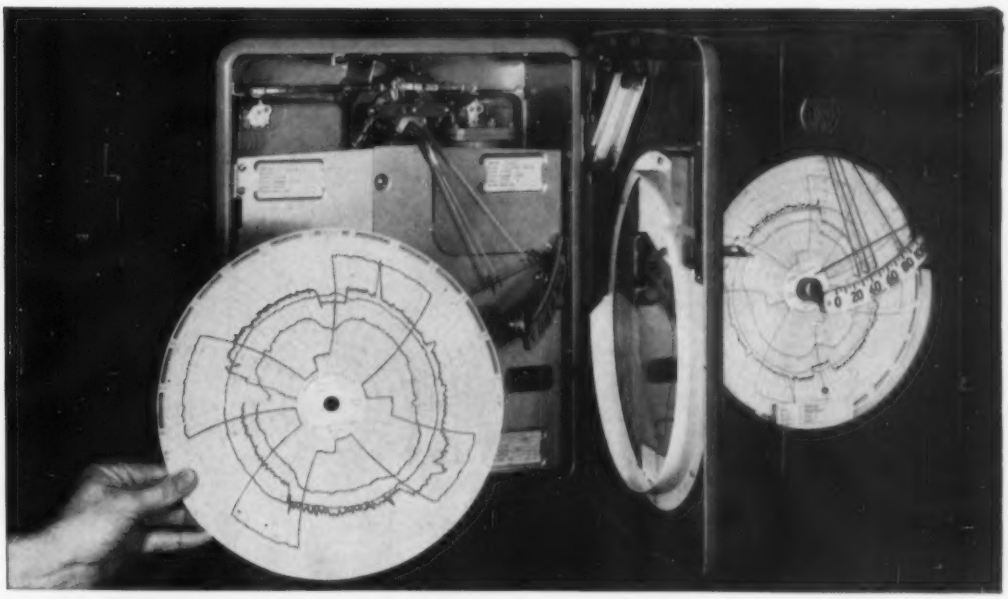
Whessoe, Ltd., Works: Darlington, County Durham



Faithfully yours –

Clear, Continuous Records without Poisoning . . . on the New Bailey Recorder

★ Faithful chart records of measured variables are the key to a meaningful, dependable analysis of operating trends and conditions. Money spent for more accurate metering, for faster response, is money down the drain—*unless* it's matched with chart records that are equally accurate.

That's why these features of the new Bailey Recorder are important to you:

1. Bailey's exclusive sealed capillary-action inking system maintains continuous flow to the pen tip, and traces sharp, opaque, quick-drying records. "Poisoning" of intersecting records is practically eliminated; no blots or smears during operation or chart changing.

2. Pens are mounted on concentric centers, trace on parallel time arcs only 42/1000" apart. This simplifies analysis of two or more records.

3. Interchangeable plug-in receiver units permit practically limitless record-grouping combinations.

Write for Product Specification E12-5 and actual chart sample.

P32-1

ONLY BAILEY OFFERS ALL THESE ADVANTAGES IN A SINGLE RECORDER

- Pre-calibrated plug-in receiver units
- Up to four pneumatic or electronic receivers —or two receivers and two integrators
- Any four variables on one chart—easily read and interpreted
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Controls for
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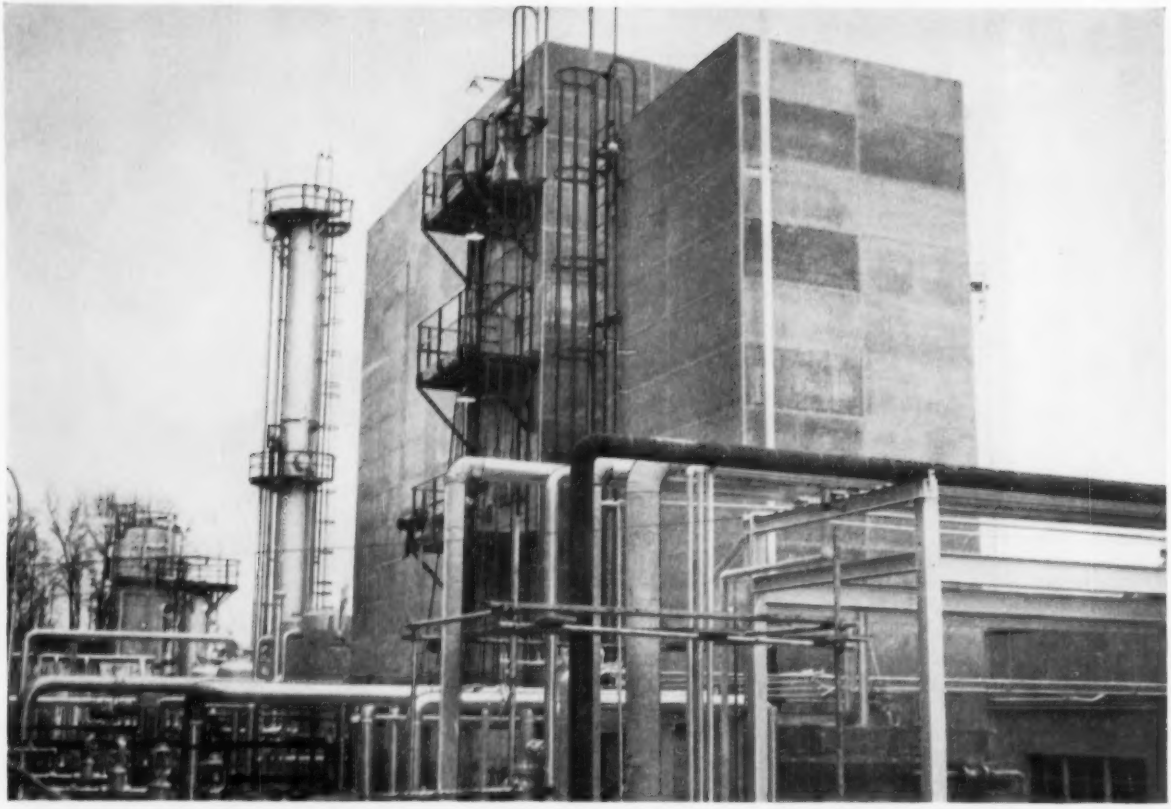

Tonnage Oxygen Unit and Ammonia Synthesis Gas Purification Unit, designed and built by Air Liquide for Mississippi River Chemical Company, in Selma, Missouri, and erected by Fluor Corp., Los Angeles, Cal.

DOES LOW-TEMPERATURE GAS SEPARATION FIGURE IN YOUR PROCESSING PLANS?

Why not consider the economic and other advantages of low-temperature gas separation methods in your processing program? Engineering specialists in this field are readily available to ensure sound modern design, top-quality fabrication of equipment, efficient erection and operation.

That special combination of knowledge and skills is at your service when you engage Air Liquide. Low-temperature gas separation has been our business for over half a century.

During the past fifty years AIR LIQUIDE has designed and built over 1000 hydrocarbon and air-separation plants for industries throughout the world, more than 150 of them in America. They are used to recover a variety of high-purity products, including Hydrogen, Carbon Monoxide, Methane, Ethylene, Oxygen, Nitrogen, and rare atmospheric gases.

Address your inquiries to: American Air Liquide, 529 Chrysler Building, New York 17, N. Y.

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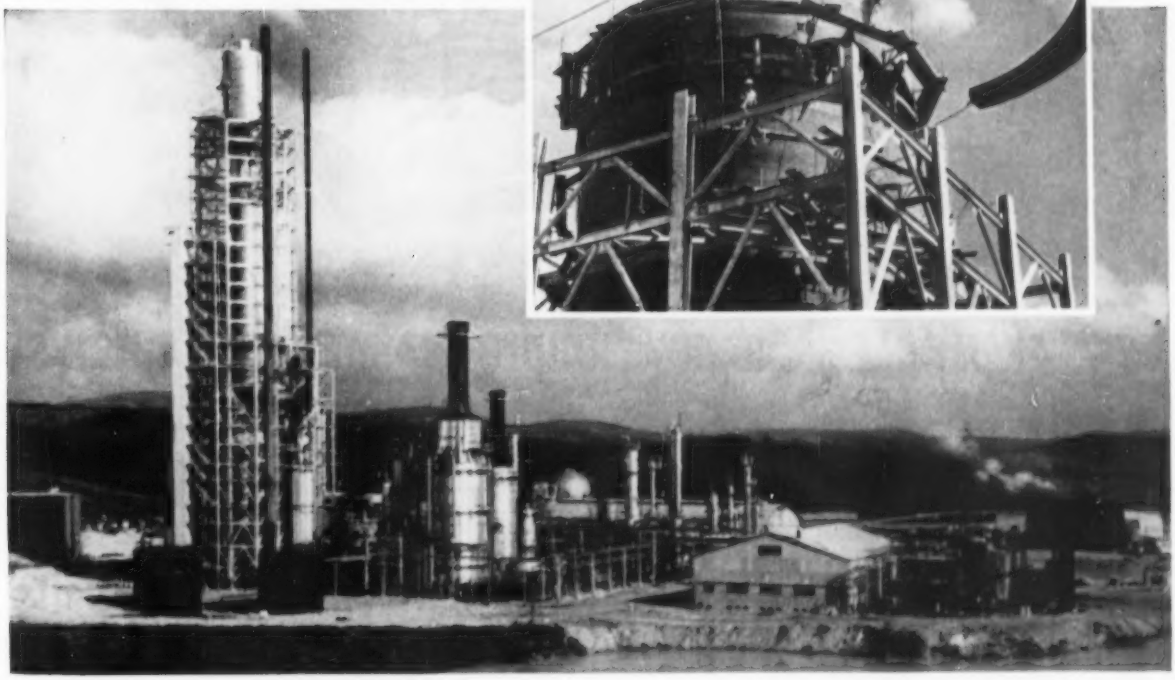
AIR LIQUIDE
ENGINEERING & CONSTRUCTION DIVISION

OLDEST IN EXPERIENCE—NEWEST IN DESIGN

529 CHRYSLER BUILDING, NEW YORK 17, N.Y.

1 ST TYPE 120 T.C.C. UNIT

erected at Capuava Refinery by CB&I



Top: An air duct section for the TCC kiln being raised into place.

Bottom: General view of Capuava Refinery.

• Fourteen miles north of Sao Paulo, Brazil, at Capuava, a main fractionating tower and the *first* type 120 Thermofor unit to be built was erected by Chicago Bridge & Iron Company in cooperation with their subsidiary, Sociedade Chibridge de Construcoes, Ltda. Both of the units were fabricated at our Greenville, Pa. plant and furnished through Hydrocarbon Research, Inc., New York, for Refinaria e Exploracao de Petroleo "UNIAO" S.A. The UNIAO refinery has a crude capacity in excess of 20,000 bbls. per day and can handle a wide variety of stocks.

• CB&I is a steel plate specialist—with *complete* facilities for designing, fabricating and erecting welded steel plate structures for the petroleum industry. Write our nearest office to take advantage of CB&I's experience and craftsmanship.

CB&I

Chicago Bridge & Iron Company

Atlanta • Birmingham • Boston • Chicago • Cleveland • Detroit • Houston
Los Angeles • New York • Philadelphia • Pittsburgh • Salt Lake City
San Francisco • Seattle • Tulsa

Plants in BIRMINGHAM, CHICAGO, SALT LAKE CITY and GREENVILLE, PA.

REPRESENTATIVES AND LICENSEES:

Brazil • Canada • England • France • Italy • Netherlands • Scotland • Venezuela

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NOW AVAILABLE... a new, improved cracking catalyst

HOUDRY MINERAL KAOLIN

for TCC and Houdriflow Moving Bed Catalytic Cracking Units

Houdry Process Corporation now offers pelleted KAOLIN, a superior natural catalytic cracking catalyst, for maximum octane at lowest cost. The high octane gasoline obtained and the low catalyst make-up required assure top performance in all TCC and Houdriflow catalytic cracking units.

Check these advantages of COMMERCIALLY PROVED Houdry Mineral Kaolin . . .

- ✓ HIGH OCTANE
- ✓ LOW COST
- ✓ HIGH ACTIVITY
- ✓ SULFUR RESISTANT
- ✓ HIGHEST THERMAL STABILITY
- ✓ EXCELLENT REGENERATION CHARACTERISTICS

HOUDRY PROCESS CORPORATION

CHEMICALS DIVISION
1528 Walnut Street, Philadelphia 2, Pa.
PIONEER IN CATALYSIS

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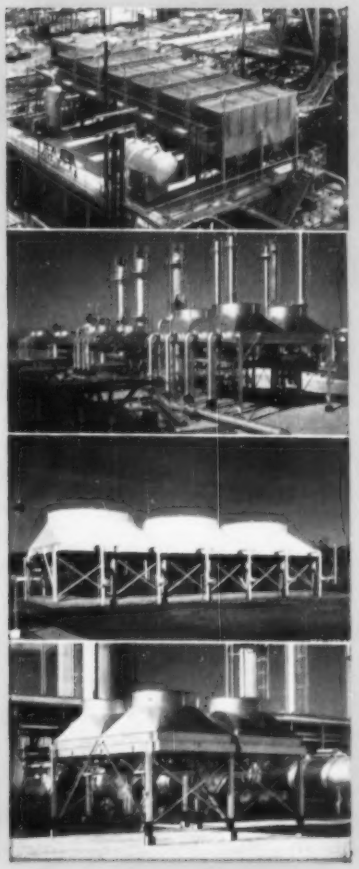
HUDSON LEADS THE WAY In Equipment For Cooling with Air

More than 600 HUDSON Solo-aire and Combin-aire Units are giving complete satisfaction both in mechanical operation and in meeting cooling performance specifications in . . .



OIL REFINERIES

Solo-aire Units, installed in space formerly occupied by water box submerged coolers, are used for condensing and oil cooling, eliminating water circulation of 4200 gallons per minute. Previous high maintenance costs due to water scaling and corrosion are also eliminated.

GAS PROCESSING PLANTS

Solo-aire Units as pictured at left, and Combin-aire Units, are minimizing water consumption, lowering water treatment costs, and lowering over-all maintenance expense in scores of Gas Processing Plants in the United States, Europe, Pakistan and South America.

COMPRESSOR STATIONS

Solo-aire Units are installed in many of the larger main line Compressor Stations in the United States for cooling gas, jacket water, and lube oil. HUDSON auto-variable pitch fans allowing accurate, automatic control of cooler outlet temperature are used in many of these installations.

CHEMICAL PLANTS

Vapor at 550°F. is condensed and condensate subcooled in Solo-aire pictured at left. In services for cooling of very high temperature fluids, and cooling of fluids with which water contamination must be avoided, Solo-aires are particularly adapted.

Experience The first HUDSON exchangers using air as the cooling medium were installed over 20 years ago for condensing exhaust steam. Thru constant research, improvement and innovation in design and in manufacturing techniques, and in development of units for special applications, HUDSON reached and has retained its position of leadership in "Cooling with Air."

HUDSON
ENGINEERING CORPORATION

FAIRVIEW STATION • HOUSTON, TEXAS

LARGE POWER SAVINGS
and Accurate, Automatic Temperature Control
with HUDSON AUTO-VARIABLE PITCH FANS

WHY do Hudson Auto-variable pitch fans on Hudson Solo-aire and Combin-aire units not only *give accurate temperature control* of cooled streams, but — *save up to 85% of fan horsepower* compared with conventional fixed pitch fans?

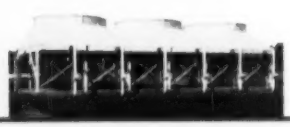
BECAUSE fixed pitch fans are usually selected to move the air required under conditions of summer air temperature and maximum heat load, and needlessly move such maximum quantity even under conditions of winter air temperatures and lower-than-design heat loads. With Hudson Auto-variable pitch fans the blade pitch is automatically controlled by outlet cooled fluid temperature so that only the quantity of air required to maintain this temperature is moved. This quantity in winter may be only 30% of that required in summer, resulting in fan horsepower saving of 85% attributable to Auto-variable pitch fans as compared with conventional fixed pitch fans.

OVER 200 AUTO-VARIABLE PITCH FANS are providing accurate, trouble-free temperature control in Hudson Solo-aire and Combin-aire units. Minute changes in cooled fluid outlet temperature immediately and automatically changes pitch of fan blades, increasing or decreasing flow. Control is effective despite changes in heat load or hot fluid inlet temperature; and over ambient air temperature range of more than 150° F.

Consult Hudson for more detailed information on the application of Auto-variable pitch fans to present or future installations.

HUDSON AUTO-VARIABLE PITCH FANS

- **Accurately control temperature.**
- **Effect major savings in power.**
- **Reduce cost of control equipment.**
- **Eliminate by-pass piping.**
- **Prevent freezing even in extremely cold weather.**
- **Operate with standard pneumatic instruments.**
- **Have all moving parts of control mechanism completely enclosed and weather-proofed.**



HUDSON
ENGINEERING CORPORATION

FAIRVIEW STATION • HOUSTON, TEXAS

Corrosioneering News

Quick facts about the services and equipment Pfaudler offers to help you reduce corrosion and processing cost.

Published by The Pfaudler Co., Rochester, N.Y.

Now you can outsert leaflets on most packages *without hand labor!*

Put your product story where it will be read—on a leaflet fastened to the outside of your package. You can do this, without slowing down your production line or using costly hand labor, by using Pfaudler's new fast-action Outsert Applicator, Model OA-3MC.

Up to 220 containers per minute

The Pfaudler Outsert Applicator attaches your message to all cylindrical containers of plastic, glass, paper, or metal—2⅝ to 7¼ inches in length, 1¼ to 6½ inches outside diameter. (Special designs for containers outside these limits.)

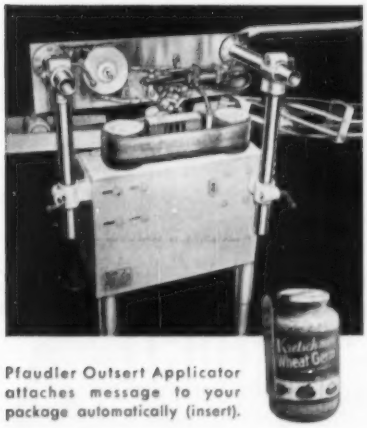
Fits right into your production line

The unit fits readily into most production line setups, *requires only four square feet of floor space!* There it operates automatically and continuously, gripping free-rolling containers from your labeling machine and forwarding them, with leaflet accurately attached, to the casing machine, ready to pack and ship.

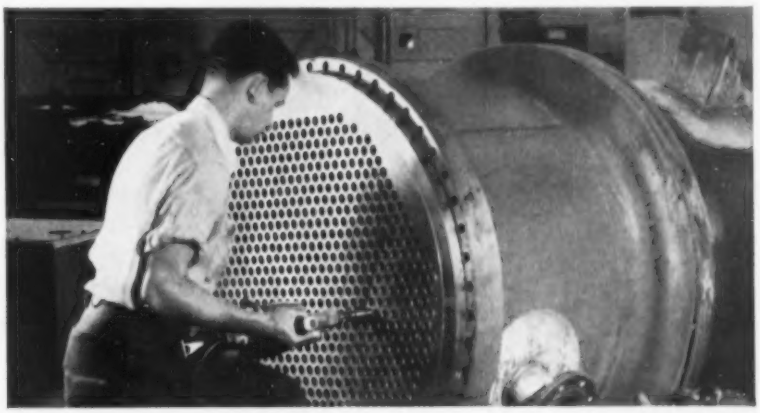
Low maintenance cost

Advanced design and careful selection of materials give you a durable machine, capable of long continuous runs. And there are no delicate mechanisms to fail.

If you're interested in the advantages of outserts for your product, simply forward a sample labeled container with outsert affixed correctly. Pfaudler engineers will analyze your requirements and send you full information. Or, if you prefer, write for Bulletin 933.



Pfaudler Outsert Applicator attaches message to your package automatically (insert).



GET 2-WEEK DELIVERY

on these flexible standard heat exchangers

Interchangeable parts are essential to the cornerstones of industrial progress. But in the chemical processing field, standardization is hard to achieve because of the great variety of requirements. Traditionally each system has had to be specially engineered.

Today it is unnecessary, in many cases, to delay your operation by waiting months for "made-to-order" heat exchangers. With the flexibility provided in Pfaudler's standard line of equipment, you can solve many process problems in two weeks—without resorting to special complicated designs.

Any one of the five sizes of Pfaudler stainless steel heat exchangers listed below can be speeded on its way to your plant.

Pfaudler's new stocking program, plus standard design, make this "off-the-shelf" delivery possible. These units are ready for almost immediate shipment and are all fixed-tube sheet design. Shell and baffles are made of carbon steel; tubes, tube sheets and bonnets are stainless steel.

These stock units may be used in vertical, horizontal or inclined positions, as specified on your order.

General specifications:

Design Pressure: 150 psi shell side; 75 psi tube side.

Design Temperature: 350° F.

Shell and Baffles: Carbon steel.

Tubes: Stainless steel, Type 316, ¾" O.D., 18 gauge, welded.

Code: Built to ASME Code U-69, but not stamped unless specified.

Diaphragm: None.

Support Lugs, Ears or Saddles: Shipped unattached, or, attached if desired location furnished.

Tube Sheets and Bonnets: Stainless steel, Type 316.

Stockpiled sizes

56 sq. ft. size—8" nominal shell diameter; 72" tube length; baffles on 4" centers.

104 sq. ft. size—10" nominal shell diameter; 96" tube length; baffles on 5" centers.

148 sq. ft. size—10" nominal shell diameter; 120" tube length; baffles on 5" centers.

216 sq. ft. size—12" nominal shell diameter; 120" tube length; baffles of 6" centers.

316 sq. ft. size—14" nominal shell diameter; 144" tube length; baffles on 7" centers.

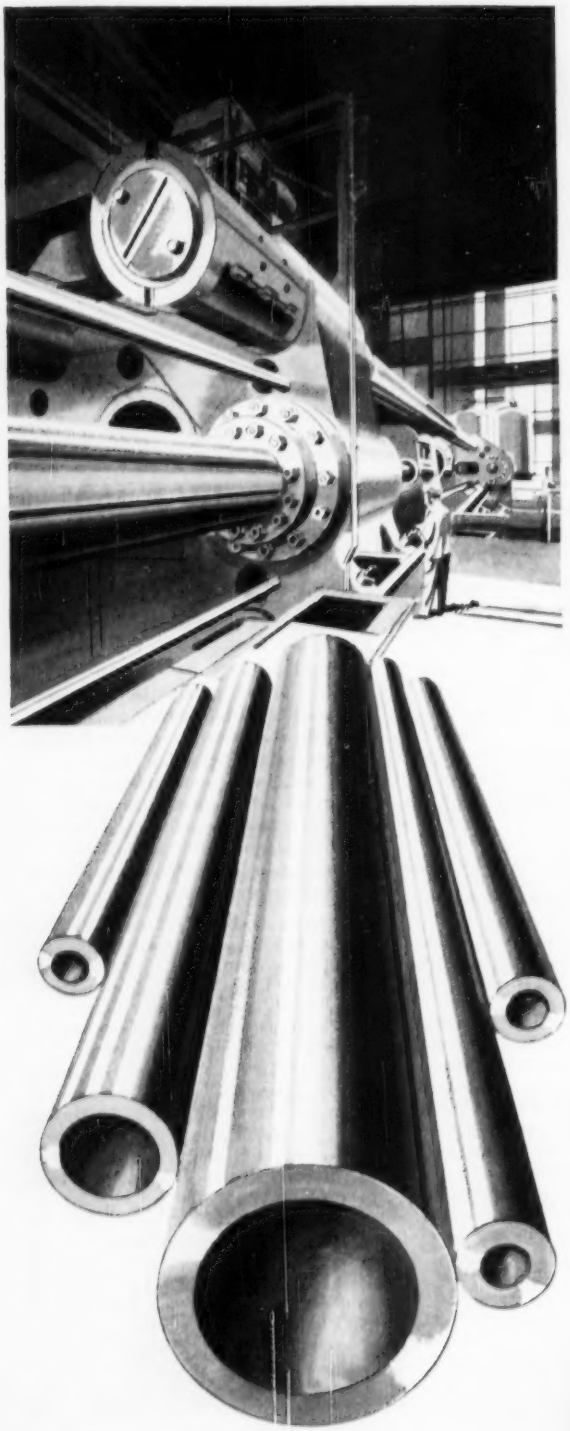
If none of these exactly fit your needs, a wide variety of other sizes are also available for fast delivery. We can help you with unusual jobs, too. Please ask us about them.

Pfaudler will build heat exchangers to meet your special requirements in many different alloys including Nickel, Inconel, Monel, Hastelloy, Titanium and Karbate. Although Pfaudler standards are based on ¾" tubes, we can give you designs for any required tube size, and any temperature or pressure.

Engineers in the Pfaudler heat exchanger design department are at your service to work out the answers with you. Why not get in touch with them when you have a special heat exchanger problem? And write for your free copy of Manual Number 837 titled, "Pfaudler Heat Exchangers and Condensers." This manual contains valuable performance and thermal design data as well as a complete description of Pfaudler heat exchangers and condensers.

For more data on advertised products, use Readers' Service Cards, last page.

NOW! from the world's largest horizontal steel extrusion press...



SEAMLESS

HEAVY WALL PIPE

from any ferrous alloy

Now heavy wall pipe can be extruded from any ferrous alloy — in lengths up to 50 feet or more, with O.D.'s from 4″ to 22″, and with virtually no restriction on wall thickness.

The giant Curtiss-Wright horizontal extrusion press, now operating at the Metals Processing Division, *moves* the metal instead of *removing* it, for pipe of maximum length — and strength.

If your application calls for higher heat, corrosion and/or abrasion resistance — in pipe of highest tensile and yield strengths — Metals Processing Division is geared to fill the requirement. Complete facilities for handling any ferrous alloy, including the stainless series, as well as titanium and other reactive metals, are available to the chemical, petroleum, power and other key industries.

Take advantage of this new, aggressive facility for your pipe requirements. Write, wire or telephone for detailed information or engineering consultation today. Our field engineers are at your service.

METALS PROCESSING DIVISION
CURTISS-WRIGHT
CORPORATION • BUFFALO, NEW YORK

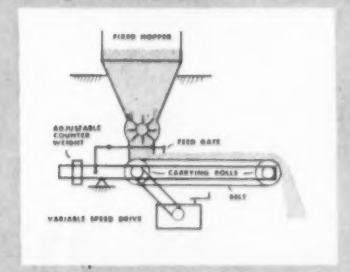
For more data on advertised products, use Readers' Service Cards, last page.

WHY NOT FEED BY WEIGHT?

TECHNICAL DATA

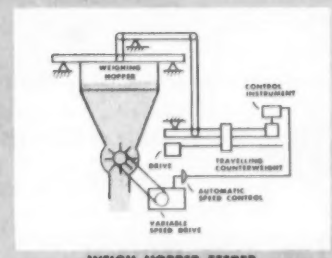
Two types of weighing feeders are commonly used in continuous processing . . . (a) The Weigh Belt, and (b) The Weigh Hopper.

In an Omega **weigh belt** feeder, the hopper is supported independently of the feeding mechanism. A lever system supports belt and its carrying rolls . . . with an adjustable counterweight permitting a predetermined weight (in terms of pounds per foot) to be continuously delivered to the process when belt is driven at uniform rate of speed. Changes in feed rate are made by either increasing or decreasing speed of belt through a variable speed transmission or by adjusting material thickness by altering counterweight position.



WEIGH BELT FEEDER

Belt feeder models range from feed rates of ½ lb. per minute to 10,000 lbs. per hour and perform within accuracies of plus or minus 1%. Sampling chutes permit close check of feed settings.

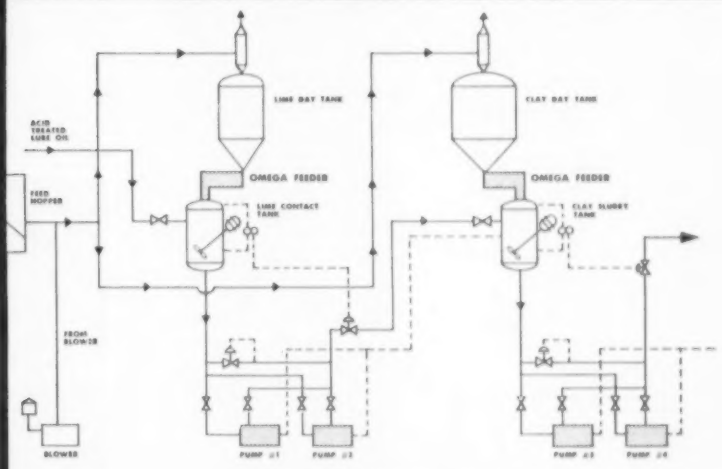


WEIGH HOPPER FEEDER

In an Omega **weigh hopper feeder** (loss-in-weight), the entire weight of hopper containing material to be fed is supported on a lever system counterbalanced by beam with traveling poise. A variable speed transmission between motor and poise drive permits adjustment of feed rate . . . and a control instrument at outboard end of beam automatically regulates material feed rate from hopper to keep beam in balance.

Loss-in-weight feeders range in capacity from a few pounds per hour to hundreds of pounds per hour . . . and are suitable for either liquids or dry materials. Feed accuracy is within ten pounds in 5,000 pounds . . . and repeat settings can be checked to a fraction of a percent.

"THE BEST COSTS LESS"



PARTIAL VIEW OF CLAY CONTACTING PROCESS

WEIGHT AUTOMATICALLY CORRECTS FOR VARIABLES IN MATERIAL BEING HANDLED!

THE PROBLEM:

Refiners utilizing the continuous clay contacting method for controlled decolorization of lube stocks are faced with the problem of proper equipment selection. This equipment must be able to continuously add the neutralizing and decolorizing agents to a stream of acid treated lube stock . . . and still permit ready dry material weight adjustment to assure correct end-product quality prior to filtration.

THE ANSWER:

OMEGA feeding methods are described briefly in the Technical Data column on the left. The selection of the feeder best suited to the process under consideration depends upon the accuracy requirements . . . as well as the initial cost of the equipment. Complete data is available upon request.

FEATURES:

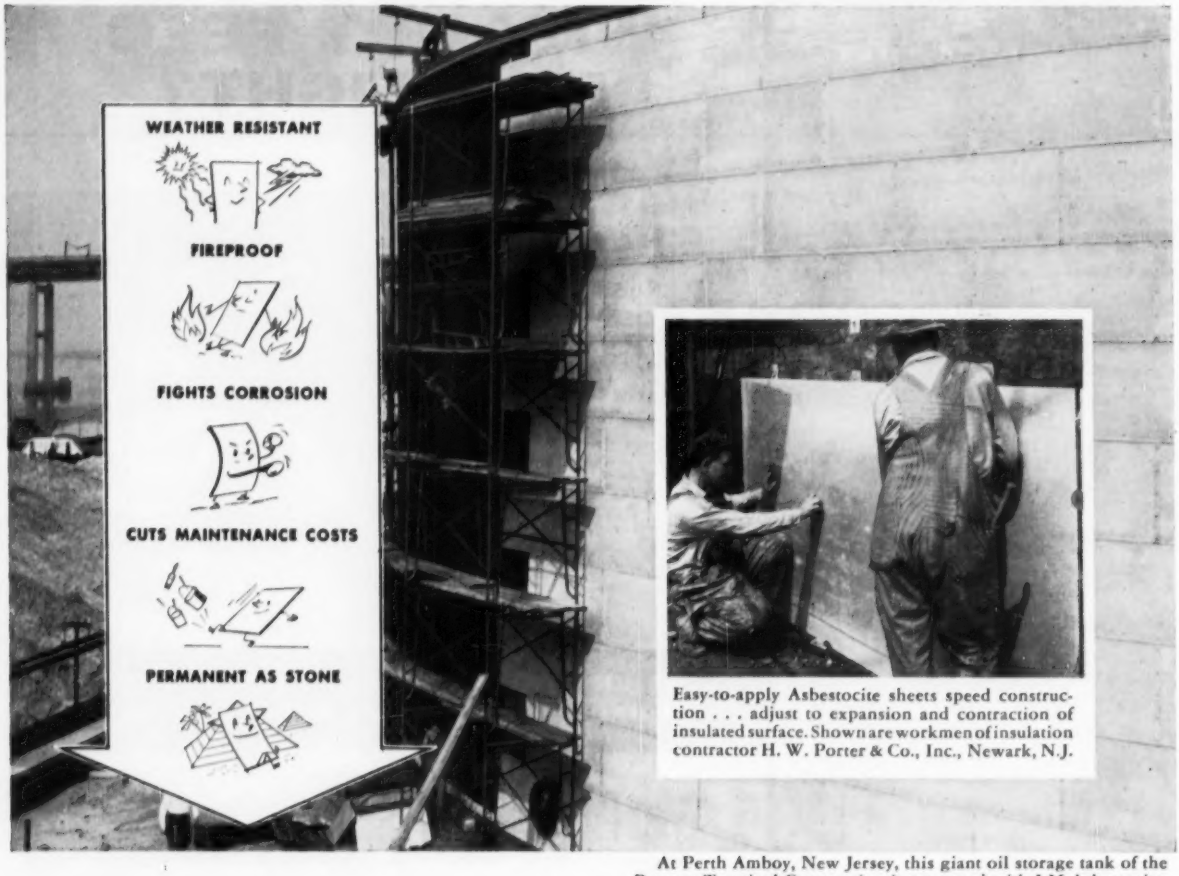
- ★ Uniform dispersion
- ★ Reduced clay consumption
- ★ Increased process efficiency
- ★ Instantaneous ratio control (clay to oil)
- ★ Uniform end-product quality

For additional data . . . write Petro Sales Department, **B-I-F Industries, Inc., 412** Harris Avenue, Providence, Rhode Island.

B-I-F INDUSTRIES
PROVIDENCE, RHODE ISLAND
B-I-F METERS FEEDERS CONTROLS

BUILDERS IRON FOUNDRY • PROPORTIONEERS, INC. • OMEGA MACHINE CO. • BUILDERS-PROVIDENCE, INC.

For more data on advertised products, use Readers' Service Cards, last page.



Easy-to-apply Asbestocite sheets speed construction . . . adjust to expansion and contraction of insulated surface. Shown are workmen of insulation contractor H. W. Porter & Co., Inc., Newark, N.J.

At Perth Amboy, New Jersey, this giant oil storage tank of the Reserve Terminal Corporation is protected with J-M Asbestocite.

5 reasons why J-M Asbestocite® asbestos-cement sheets

give insulated equipment more protection per dollar

NO OUTDOOR INSULATION JOB is really complete unless it is provided with permanent protection against weather. That's why so many engineers specify Johns-Manville Asbestocite® for protecting insulated tanks, vessels, towers, stacks and other outdoor equipment.

Asbestocite combines these five important advantages in one material:

Weather resistant—Asbestocite is unaffected by exposure to sun, wind, rain, snow or temperature extremes.

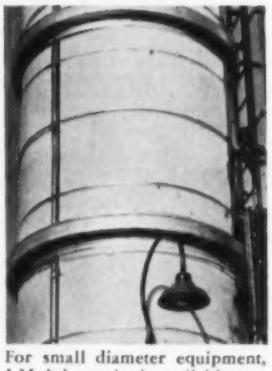
Fireproof—Made of cement and asbestos, inorganic Asbestocite will not burn . . . approved by Underwriters' Laboratories as incombustible.

Fights corrosion—Nonmetallic, Asbestocite is immune to most corrosive elements found in industrial atmospheres.

Cuts maintenance costs—Under normal conditions, Asbestocite maintains its neat, attractive appearance with little or no maintenance. Needs no preservative treatment.

Permanent as stone—Stonelike Asbestocite is practically indestructible. It has virtually unlimited service life.

J-M Asbestocite is made of asbestos and cement combined under tremendous pressure into a uniform, monolithic sheet. Its stone-grey color provides a handsome appearance. Write for free brochures IN-121A and IN-173A. Address Johns-Manville, Box 60, New York 16, N. Y. In Canada, Port Credit, Ontario.



For small diameter equipment, J-M Asbestocite is available *precurved* for easier application and snugger fit as shown above on vessel at Standard Oil Company of California's Richmond refinery.

JM PRODUCTS

Johns-Manville *first-in* **INSULATION**

MATERIALS · ENGINEERING · APPLICATION

BLAW-KNOX Autoclaves furnished in a size and type

. . . for every pressure and temperature application

with all auxiliary equipment, when desired, for a complete high pressure plant

Blaw-Knox has designed, constructed and equipped autoclaves in all practical sizes, ranging from one quart capacity upward to the largest commercial sizes with total capacities of several thousand gallons.

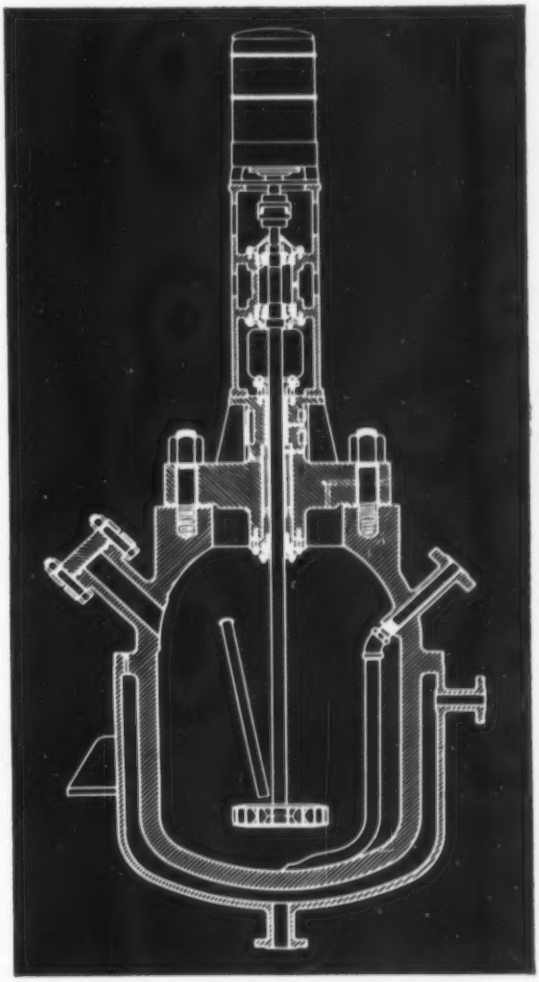
Pressure requirements range widely from vacuum and atmospheric operations up to several thousand pounds per square inch. Temperatures, where required, cover a full range starting at sub-zero temperatures and going as high as commercial needs dictate, some operating at 800° F. and higher, with heating methods ranging with the temperatures to be reached.

Any suitable material of construction is used, the choice depending on the materials and conditions of the reaction under consideration. Many different agitator types are available to meet every conceivable mixing requirement.

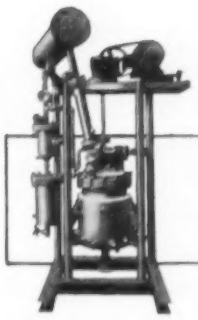
In other words, Blaw-Knox has the engineering knowledge and skill and the manufacturing facilities to build any size, any type autoclave or kettle for use for hydrogenation, ammonolysis, polymerization, or organic synthesis, for batch products of chemicals, drugs and medicines or resins, and for general chemical processing.

No matter what your reaction problem is, whether with low pressure—low temperature, or highest pressure—high temperature conditions, why not discuss it with us. We will gladly give you our recommendations.

Ask for Catalog 2413-R.



Drawing of a Blaw-Knox 120-gallon Steam Jacketed Autoclave, with turbine agitator, for processing organic chemicals at a pressure of 2000 psi and a temperature of 300° F.



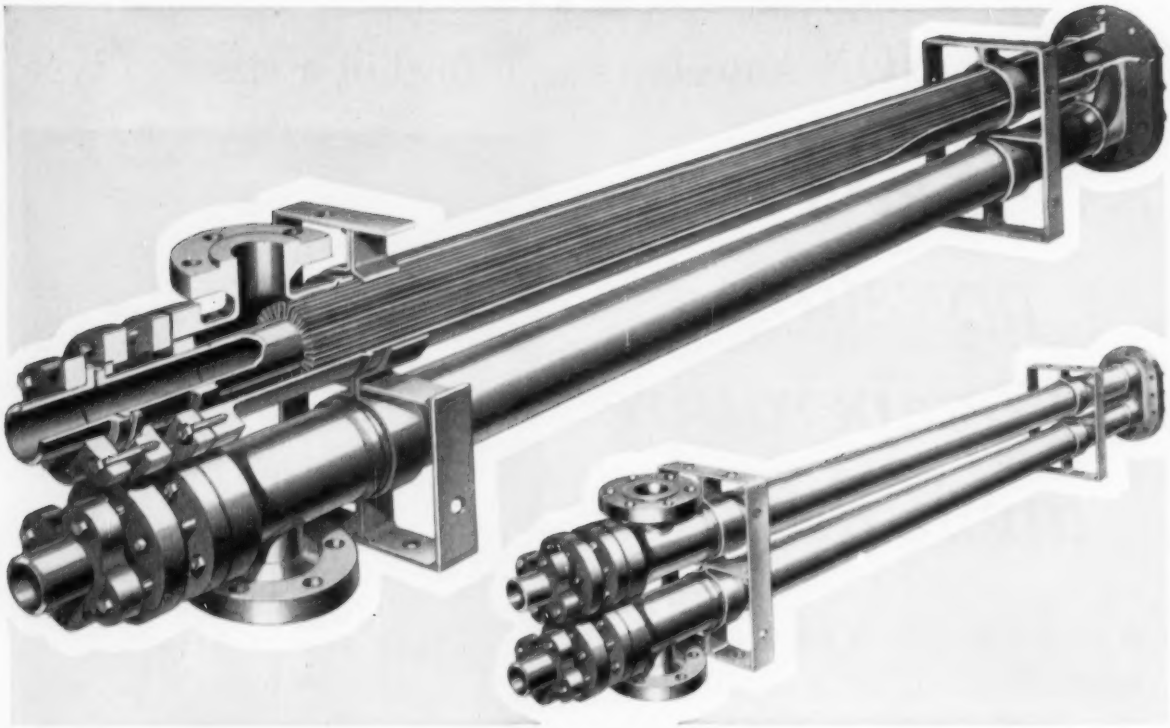
Photograph of a Blaw-Knox 15-gallon Electro-Vapor Processing Kettle, widely used in the resin and chemical industries.

50th Anniversary BLAW-KNOX 1906-1956

BLAW-KNOX COMPANY

Buflovak Equipment Division, 1601 Fillmore Avenue, Buffalo 11, N. Y.

For more data on advertised products, use Readers' Service Cards, last page.



NEW ALCOTWIN HEAT EXCHANGERS GIVE "BUILDING BLOCK" FLEXIBILITY, UNEQUALLED HEAT TRANSFER

ALCOTWIN heat exchangers provide economical, high performance in package form. Their double-pipe fin tubes, with a high ratio of extended surface, make them particularly adapted to water-cooled or vapor-heated services.

Easily arranged and supplemented, ALCOTWINS readily meet changing load and process requirements. Unlike conventional shell-and-tube heat exchangers, they never become obsolete.

Standardized design of the ALCOTWIN allows custom selection of metallurgy for specific service, with the economy and availability provided by "off the shelf" standard parts.

Complete data is available from any of ALCO'S sales offices. Or write P. O. Box 1065, Schenectady 1, N. Y., for brochure.

ALCO LONGITUDINAL FIN TUBES

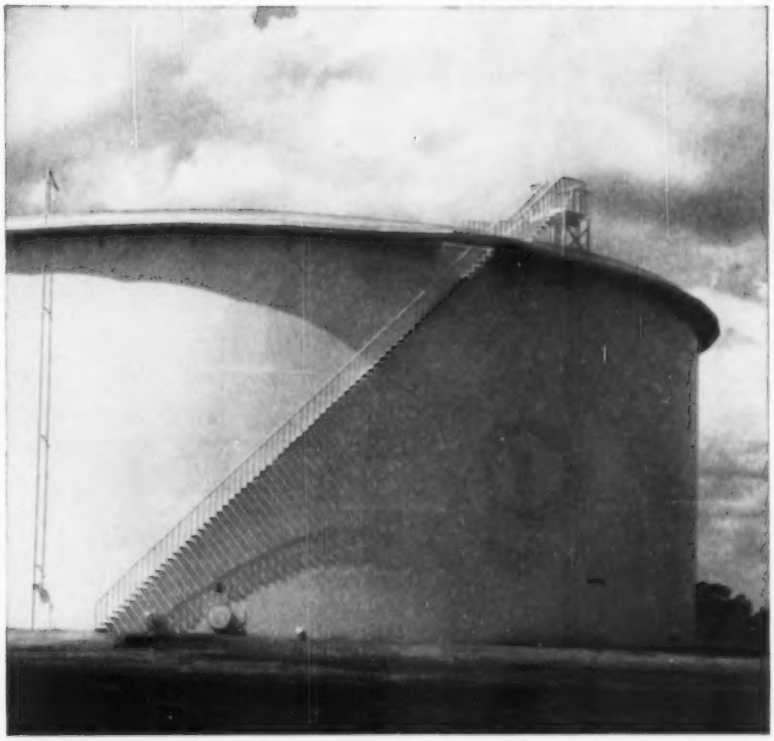
Unequalled heat-transfer characteristics result from the fused metal-to-metal bond between the "U" shaped fin channels and the tube. ALCO's heliarc welding techniques provide a continuous, even bond resulting in higher efficiency.

ALCO

ALCO PRODUCTS, INC.

New York

Sales Offices in Principal Cities



The Sinclair Pipe Line Company and Rockwood have developed a new integrated fire protection system that is actually built into this Sinclair Pipe Line Company floating roof tank at Humboldt, Kansas.

A new approach to floating roof tank protection

Now for the first time, an integral Foam-making and Foam-distribution system that brings truly modern fire protection to floating roof tanks.

Tank fires usually occur in tanks of the floating roof type. Lightning is the chief cause of these fires.

Portable Foam hose lines could put out these vapor seal fires — *if* there was sufficient manpower — *if* the Foam lines could be placed into operation soon enough — *if* the hose streams could be brought close enough to the fire. There were too many "ifs" to this system. There must be a better way — and there was!

Rockwood, working in conjunction with Sinclair Pipe Line Company, developed a unique and practical method —

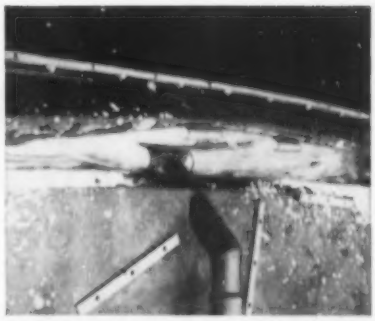
A compact, more economical, more effective integrated system that is actually built into the tank! This system insures speedy Foam delivery and distribution in the critical vapor seal space between the tank wall and the floating roof.

Here's an entirely new approach to protecting floating roof tanks. It not only minimizes losses, but permits the fire to be put out by one man if necessary and increases the safety of fire fighting personnel. Write for full information on this unique fire fighting idea!

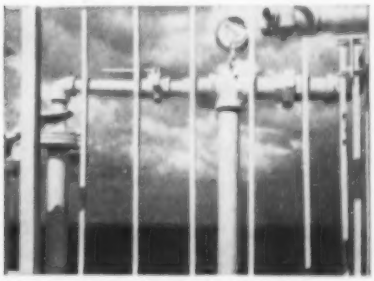
ROCKWOOD SPRINKLER COMPANY

Engineers Water . . . to Cut Fire Losses

Distributors in all principal cities



Tee-shaped Distributor Nozzle discharging Foam from Rockwood Foam Maker Unit into vapor seal space between floating roof and tank wall.



This stair platform at top of tank shows the Foam Hydrant (top right) and Rockwood Foam Maker Unit (center) which is located so as to deliver Foam to roof area below stair platform.

Gasoline engine driven fire pump, Foam liquid storage tank and Rockwood around-the-pump Foam proportioning system at Sinclair's Humboldt Station. This unit has a Rockwood "L" type Metering Valve and Rockwood "B" proportioner.

ROCKWOOD SPRINKLER COMPANY
Portable Fire Protection Division
1601 Harlow Street
Worcester 5, Mass.

Please send me full information on the Rockwood Integral Foam-making and distribution system.

Name.....

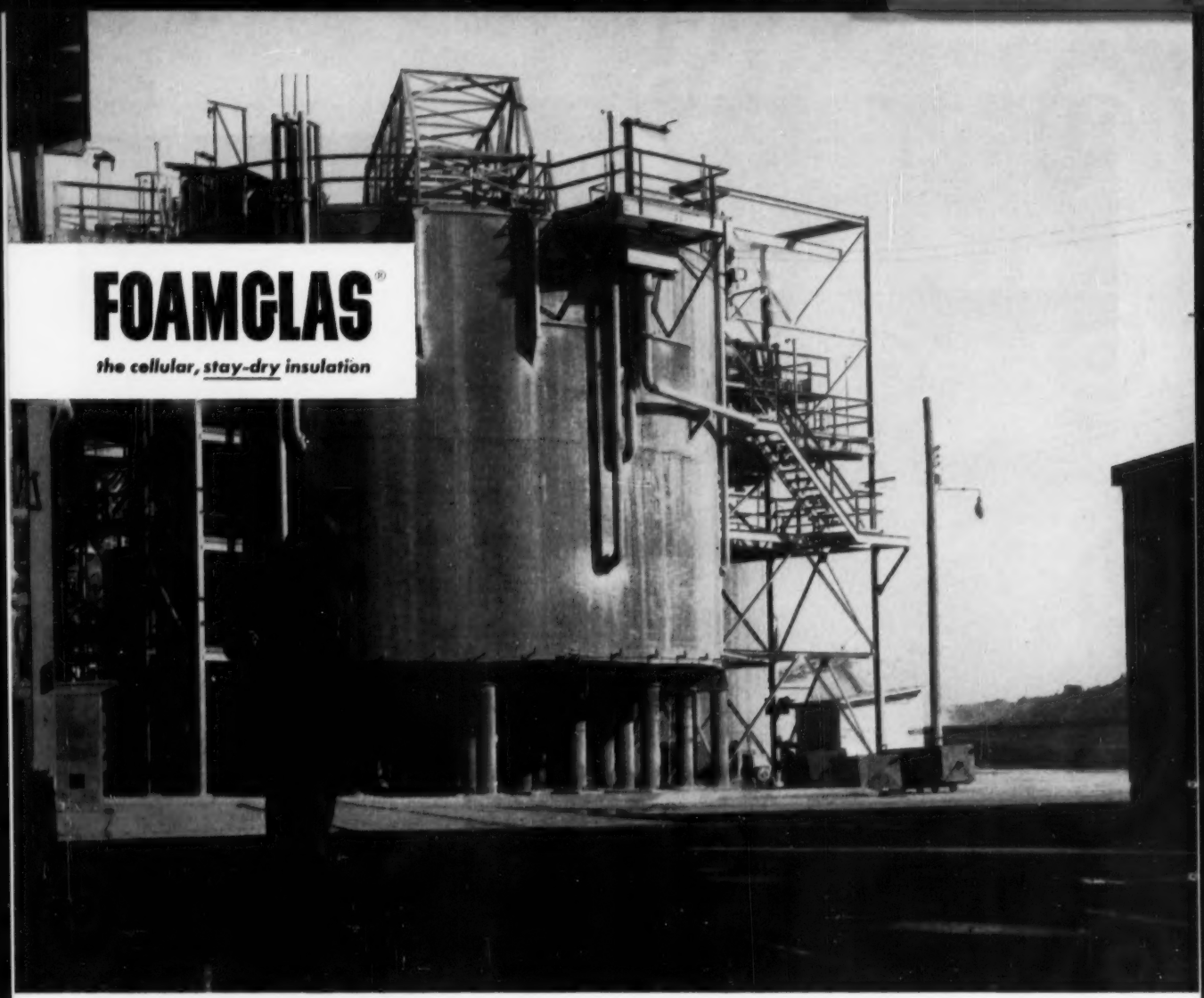
Title.....

Company.....

Street.....

City.....Zone...State.....

For more data on advertised products, use Readers' Service Cards, last page.



FOAMGLAS®

the cellular, stay-dry insulation

At the Baton Rouge Plant of Kaiser Aluminum & Chemical Corporation

Stay-dry FOAMGLAS insulation beats humidity, prevents corrosion on process tanks and vessels

Four years ago FOAMGLAS was installed on various process tanks and vessels at Kaiser Aluminum & Chemical Corporation's Baton Rouge, Louisiana plant. They needed a moisture resistant insulating material which could withstand high and rapidly changing humidity.

Because FOAMGLAS *stays dry* it was installed on hot water tanks and sodium aluminate process vessels varying in capacity from 2000 to 400,000 gallons. The moisture-proof structure of FOAMGLAS is giving *constant insulating protection* and is effectively preventing corrosion . . . despite the severe humidity conditions. Because it's fireproof FOAMGLAS is also providing an added safety factor.

These benefits and more can be *yours* when you insulate vessels, piping, equipment or buildings with long-lasting, *stay-dry* FOAMGLAS. Write for full details. We'll be happy to send you a free sample and our latest literature pertinent to your needs.

Pittsburgh Corning Corporation

Department Z-66, One Gateway Center
Pittsburgh 22, Pennsylvania
In Canada: 57 Bloor St. W., Toronto, Ontario

Also manufacturers of PC Glass Blocks

You can easily prove that FOAMGLAS stays dry by making this simple test. It and five other equally simple tests will quickly demonstrate the combination of properties that make FOAMGLAS the perfect solution to your insulating problems. Write now for a free sample and complete testing directions.

SIMPLIFIES DESIGN

SIMPLIFIES BUYING

SIMPLIFIES INSTALLATION

Makes your work easier!

EVERYONE who specifies, buys and uses welding fittings and flanges has a mighty good reason for insisting on TUBE-TURN* products. *They simplify his work!* Being the world's most complete line, they *simplify piping design.* All available from one nearby source, they *simplify purchasing.* Of unsurpassed uniformity, they *simplify installation.*

These cost-cutting advantages are yours at no extra cost when you specify TUBE-TURN Welding Fittings and Flanges and buy from your nearby Tube Turns' Distributor. You get *more for your dollar* with this leading brand!

The Leading Manufacturer of Welding Fittings and Flanges

TUBE TURNS LOUISVILLE 1 KENTUCKY

A DIVISION OF NATIONAL CYLINDER GAS COMPANY

DISTRICT OFFICES: New York • Philadelphia • Pittsburgh • Cleveland • Detroit • Chicago
Kansas City • Denver • Los Angeles • San Francisco • Seattle • Atlanta
Tulsa • Houston • Dallas • Midland, Texas

*"TUBE-TURN" and "tt" Reg. U.S. Pat. Off.

HERE'S HOW...

How TUBE-TURN Welding Fittings and Flanges

SIMPLIFY YOUR WORK

ENGINEERING

You can specify TUBE-TURN Welding Fittings and Flanges and know that you'll get the exact answer to your problem. The line includes all types in all piping materials, schedules and sizes. Also, Tube Turns offers you engineering assistance and helpful design literature.

PURCHASING

Tube Turns offers you outstanding distributor service . . . local stocks, geared for fast service. You can depend on this source for *all* your needs in welding fittings and flanges. One order . . . one source saves purchasing time.

INSTALLATION

Welders are enthusiastic about TUBE-TURN products because they fit up true, and elbows can be cut to odd angles with perfect alignment. Rigid inspection and quality control by Tube Turns assures absolute dimensional accuracy and uniformity.

NEW BOOKLET—This new Tube Turns' booklet gives helpful information on pipe, fitting and flange materials. Mail the coupon for your free copy.

TUBE TURNS, Dept. Y-3
224 East Broadway, Louisville 1, Kentucky

Please send free copy of Pipe, Fitting and Flange Materials.

Company Name _____

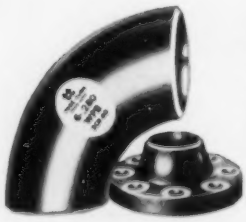
Company Address _____

City _____ *Zone* ____ *State* _____

Your Name _____

Position _____

Available from your nearby TUBE TURNS' distributor



DISTRICT OFFICES:

New York	Los Angeles
Philadelphia	San Francisco
Pittsburgh	Seattle
Cleveland	Atlanta
Detroit	Tulsa
Chicago	Houston
Kansas City	Dallas
Denver	Midland, Texas

*"TUBE-TURN" and "⁂" Reg. U. S. Pat. Off.

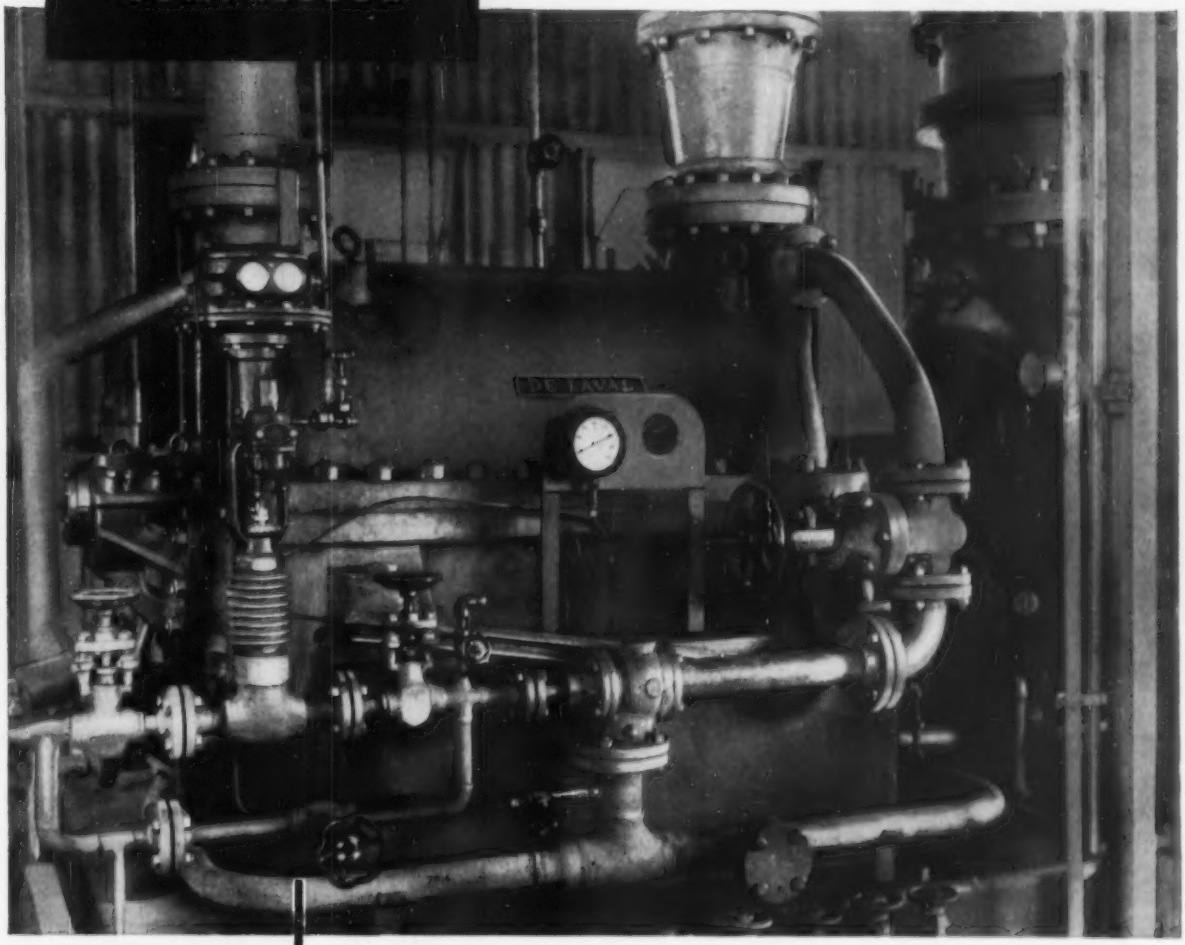
TUBE TURNS

LOUISVILLE 1, KENTUCKY

A DIVISION OF NATIONAL CYLINDER GAS COMPANY

DE LAVAL CENTRIFUGAL COMPRESSOR

handles hydrocarbon gas in Sunray Oil refinery



Send for new Bulletin 0504

This De Laval 7-stage centrifugal gas compressor, installed at the Duncan, Oklahoma refinery of the Sunray Oil Company, handles a heavy hydrocarbon gas in a delayed coking process. The gas has a molecular weight of 31.5.

The De Laval centrifugal compressor is rated at 2840 inlet cfm; discharge pressure is 240 psia. The power required is 1350 bhp with compressor operating at 9900 rpm.

Sunray Oil is another refinery which has selected De Laval compressors for heavy-duty continuous service. Rugged, horizontally split casings, individually designed impellers, perfectly balanced rotors and externally mounted, cylindrically seated bearings are design features that assure optimum performance and long service.

DE LAVAL *Centrifugal Blowers*

DE LAVAL STEAM TURBINE COMPANY
811 Nottingham Way, Trenton 2, New Jersey

DL 327

STAYNEW

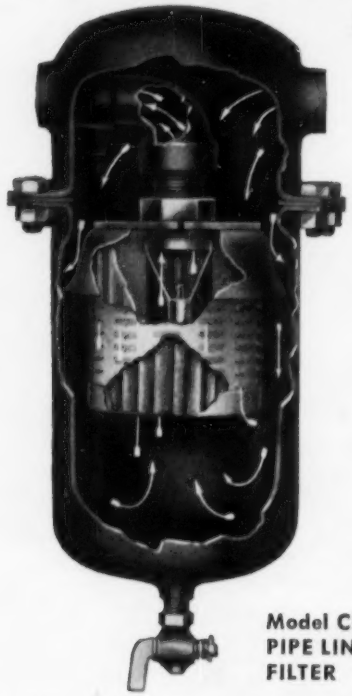
PIPE LINE FILTERS

FOR

CLEAN DRY AIR

IN

- AIR OPERATED INSTRUMENTS
- AIR OPERATED TOOLS
- PNEUMATIC CONTROLS
- INDUSTRIAL PROCESSES

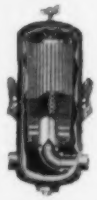


Model CPH PIPE LINE FILTER

MODEL CPH PIPE LINE FILTER has exclusive Staynew "double action principle." Air is first deflected to outer walls of filter and forced downward at high speed. Water, oil and heavier particles of rust, etc., are thus deposited in base. Mechanically cleaned air then rises to pass through filtering medium which removes lighter airborne particles. This double action design eliminates need for frequent cleaning.

Inexpensive, simple to install and maintain, Staynew Pipe Line Filters keep your air-operated equipment free from the destructive effects of pipe scale, dust, dirt, and condensates. And, Staynew Filters pay for themselves in reduced equipment maintenance costs alone. They filter compressed air under all pressures and temperatures, natural and manufactured gases. Dollinger engineers will welcome your filtration problems. Why not call on us. Remember, Dollinger *makes* every type of filter for every industrial need.

INTAKE FILTERS

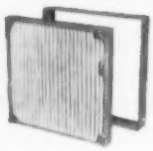


LIQUID FILTERS

PIPE LINE FILTERS

ELECTRO-STAYNEW PRECIPITATOR

AUTOMATIC AIR FILTERS



PANEL FILTERS

SPECIAL FILTERS

DOLLINGER PROTECTO-MOTOR STAYNEW FILTERS

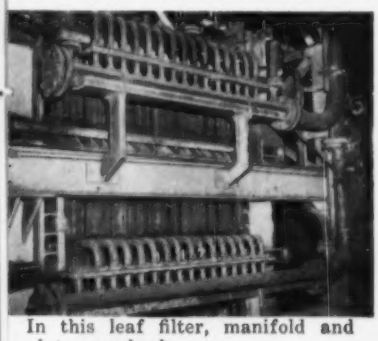
DOLLINGER CORPORATION

ALL TYPES OF FILTERS FOR EVERY INDUSTRIAL NEED

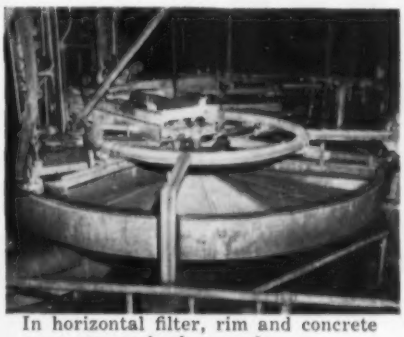
Write for Bulletin 200 which contains complete engineering data and illustrated material on Staynew Pipe Line Filters. Dollinger Corporation, Dept. 47, Centre Park, Rochester 3, N. Y.

LIQUID FILTERS • PIPE LINE FILTERS • INTAKE FILTERS • HYDRAULIC FILTERS
ELECTROSTATIC FILTERS • DRY PANEL FILTERS • SPECIAL DESIGN FILTERS
VISCOUS PANEL FILTERS • LOW PRESSURE FILTERS • HIGH PRESSURE FILTERS
AUTOMATIC VENTILATION FILTERS • NATURAL GAS FILTERS • SILENCER FILTERS

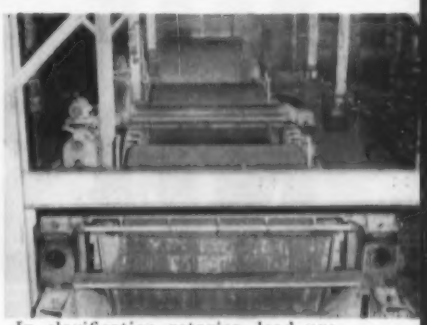
"We rely on lead at every stage of acid handling" says large chemical processor



In this leaf filter, manifold and plates are lead



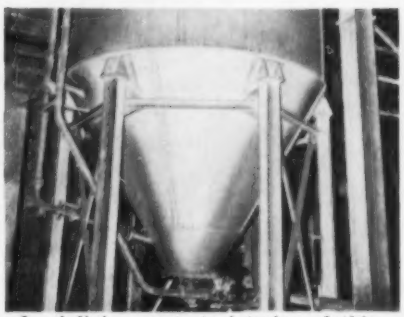
In horizontal filter, rim and concrete supports are lead-covered



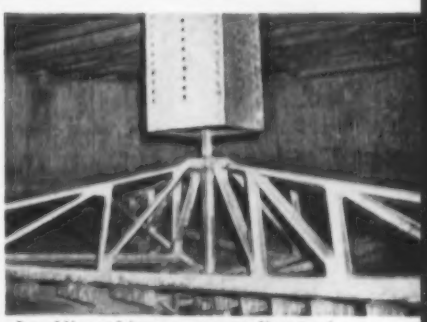
In clarification rotaries, lead protects parts exposed to acid

"...in our filters

Lead apron 24" high guards digester rim against spill



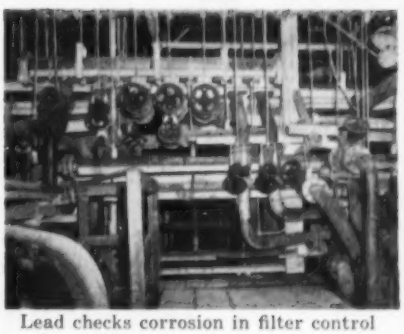
Lead lining protects interior of this steel digest tank



Lead lines this concrete settling tank, covers rake. Plows are solid lead

"...in our tanks

Lead-lined valves and piping serve digesters



Lead checks corrosion in filter control valve station

Lead stacks and flues withstand corrosive fumes.

"...in our lines...valves and pumps...and flues"

Lead's cost is low...its maintenance economical...its salvage value high

National Lead is a leading supplier of lead equipment for handling sulphuric acid solutions. If you have an acid control problem, we will be glad to help you solve it.

National Lead Company

111 Broadway, New York 6, New York

ON THE NOSE

PRECISE ALLOY MIX GIVES *extra life* TO CHASE® ANTIMONIAL ADMIRALTY HEAT EXCHANGER TUBES

Strange that such a simple little thing as weighing could add years of life to a heat exchanger tube. Yet this careful weighing, plus extra care in manufacture, is why Chase Antimonial Admiralty Heat Exchanger Tubes *do* last longer!

Thanks to this weighing process, Chase Antimonial Admiralty Heat Exchanger Tubes contain *exactly* the right combination of metals to resist the ravages of dezincification. As a result, Chase Antimonial Admiralty Heat Exchanger Tubes mean lower operating costs, fewer breakdowns, more time between tube replacements!

Next time you plan a new installation, or replace heat exchanger tubes, install Chase Antimonial Admiralty. Enjoy extra years of service!

CHASE WAREHOUSE STOCKS: Beaumont,* Houston,* Los Angeles, New Orleans, Tulsa**

*Handled by Standard Brass & Mfg. Co. **Handled by Vinson Supply Co.

Chase®

BRASS & COPPER CO.

WATERBURY 20, CONNECTICUT • SUBSIDIARY OF KENNECOTT COPPER CORPORATION

The Nation's Headquarters for Brass, Copper & Stainless Steel

Atlanta	Chicago	Denver	Indianapolis	Minneapolis	Philadelphia
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Boston	Cleveland	Grand Rapids	Los Angeles	New Orleans	Providence
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The most compact, reliable sampler ever built . . .

THE NEW Gilbarco

Small in size...
light in weight

AUTOMATIC SAMPLER

Here's a new compact, completely automatic, magnetically powered and electronically controlled sampler designed to provide a continuous sample from process or pipe lines.

USERS GET ALL THESE IMPORTANT ADVANTAGES.

- ★ Proportional to time or flow
- ★ Settings for 20 to 300 cycles per minute for more accurate sampling
- ★ No packing glands, no leakage
- ★ No electric motor, no mechanical switches
- ★ Simple to install and service
- ★ LOW initial cost . . . LOW maintenance cost
- ★ Completely explosion-proof . . . no pressure relief valves required
- ★ No hold-up time from pipe line to sample receiver; because a portion of the stream is by-passed through the sampler

Before you buy any other sampling unit, write for full details on this New Automatic Sampler.

GILBERT & BARKER MFG. CO. • WEST SPRINGFIELD, MASS. • TORONTO, CANADA

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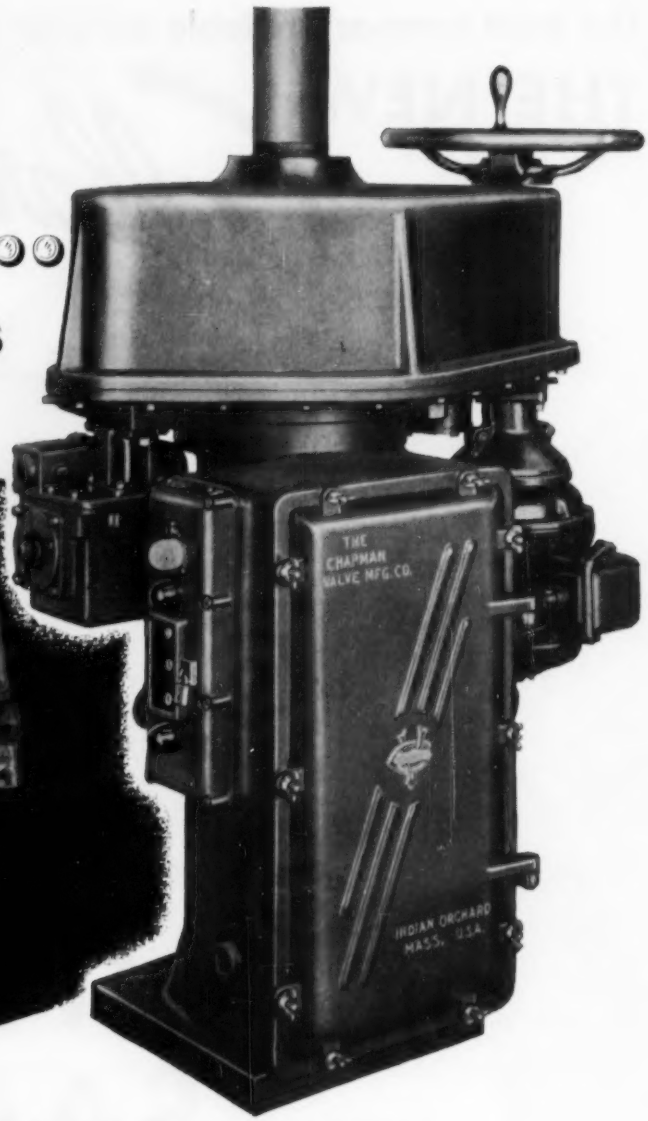
NO FRILLS..
All Business

for valves, floorstands and sluice gates



CHAPMAN MOTOR UNITS

Just look at them . . . inside as well as out. You'll find that Chapman Motor Units are not only rugged in construction, *they're simple in design.* In fact, a Chapman Motor Unit has approximately *half as many parts* as any other unit.

This simplicity means better, easier operation and lower maintenance costs. It means longer life with fewer repairs.

With Chapman Motor Units your valves seat tight . . . but never too tight. Micrometer adjustment on limit switch insures exact tightness presetting. Drift is eliminated. Lash is slashed. Complete operation by low speed motors is always smooth, accurate and trouble free.

Use them in any position. Quiet, rugged stub-tooth gears require no grease or oil. Use them under the most adverse conditions. They're weatherproof, steamtight, dependable.

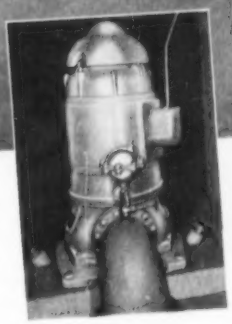
Installation is quick and easy. Chapman Motor Units and Floorstands are wired and ready to tie in with your leads. Just hitch them up. You're in business.

Get the whole interesting story in our newest catalog 51. Write for it, your copy, now.

The CHAPMAN VALVE Mfg. Co.
INDIAN ORCHARD, MASS.

For more data on advertised products, use Readers' Service Cards, last page.

It takes a lot of water . . . to make Sunshine Biscuits!

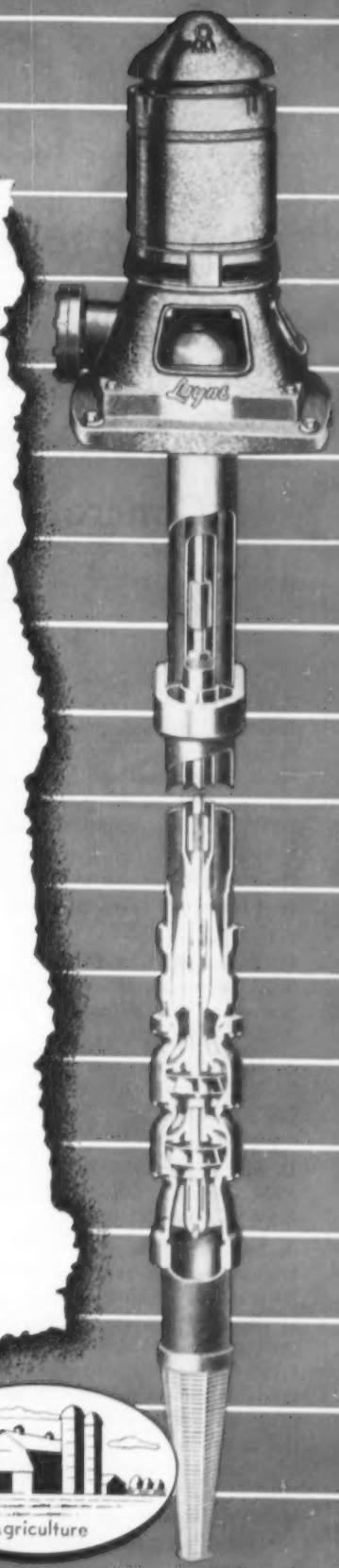


An unfailing, ever-dependable water supply is an absolute essential in producing the world-famous Sunshine biscuits.

And this is significant of the same insistence on surety of quality that is characteristic of all Sunshine operations . . . when the Kansas City, Kansas, bakery needed additional water for air conditioning and air cooling, Layne was given the entire job. Layne wells and Layne vertical turbine pumps have a capability of supplying the Kansas City bakery with nearly six million gallons of water daily. That's bringing water to Sunshine!

LAYNE
& BOWLER, INC.
MEMPHIS
General Offices and Factory

LAYNE ASSOCIATE COMPANIES THROUGHOUT THE WORLD



Layne

Water Wells • Vertical Turbine Pumps • Water Treatment

What it takes to make a 3000 Degree Refractory Concrete

Because of the widespread interest in the use of refractory castables, many furnace operators have asked us for the story behind the performance of B&W's unique refractory concrete, Kaocast.

Here are the answers to some of the most frequently asked questions:

Q. *When you refer to Kaocast as a 3000 degree refractory castable, do you mean that its melting point is 3000° F?*

A. No, this means that its service use limit is 3000° F; its melting point is 200 degrees higher.

Q. *Just what does it take to make a 3000 degree refractory castable like B&W Kaocast?*

A. Let's first define a few terms. Refractory castables are made with granular materials which are volume stable at high temperatures and which can undergo repeated heating and cooling cycles without disintegration. These materials, known as refractory calcines or grogs, are blended with suitable hydraulic binders. The initial strength of a refractory castable is thus developed in the same manner as that of ordinary concrete—that is, through the chemical action between water and the binder. A strong *ceramic bond* is formed when the refractory castable is subjected to temperatures above the vitrification point.

Q. *Then you have a grog, a binder and a method of putting them together. Which is most important?*

A. You can't say that any *one* is most important. It's a combination of all three. Let's take them one at a time. Our grog consists primarily of the proper blend of kaolin and other alumina-silica materials. This ratio enables us to achieve a grog with minimum expansion and shrinkage, a high fusion point, and greater stability under load, at varying temperatures.

Q. *And now, what about the binder?*

A. There are a number of factors responsible for the success of the Kaocast binder. One is the compound Tricalcium Penta-aluminate (3 lime to 5 alumina). This formula produces the most refractory compound (highest melting point) that can be made from lime and alumina. Another is that by using the purest commercially available lime and alumina, the Kaocast binder is substantially free of iron and silica. Such traces of these that are present combine during the pre-firing of the binder to produce stable compounds.

Q. *Just how important is the manufacturing or "blending" of the grog and the binder?*

A. If one factor could be singled out as "most important" it would be quality control.

Direct control over the fineness of materials, prefiring temperatures, and other phases of manufacture is possible at B&W because both the grog and the binder are made and blended at B&W's Augusta Works—under B&W's direct control and supervision.

Q. *These factors you've discussed must add up to some specific advantages of Kaocast. What are they?*

A. B&W Kaocast has all the advantages of easy installation which are responsible for the widespread interest in refractory concretes, plus these exclusive features: It is the only 3000 degree refractory concrete with high resistance to spalling and low volume change throughout its operating range.

THE BABCOCK & WILCOX CO.
Refractories Division
General Offices:
161 East 42nd St., New York **17, N. Y.**
Works: Augusta, Ga.

(Advertisement)

For more data on advertised products, use Readers' Service Cards, last page.

In water conditioning... one grows taller than the rest!

W. H. & L. D. BETZ, Philadelphia, Pa.

"Fishing" for Better Quality? Prompt Delivery?

Specify Acipco Spun Steel Tubes

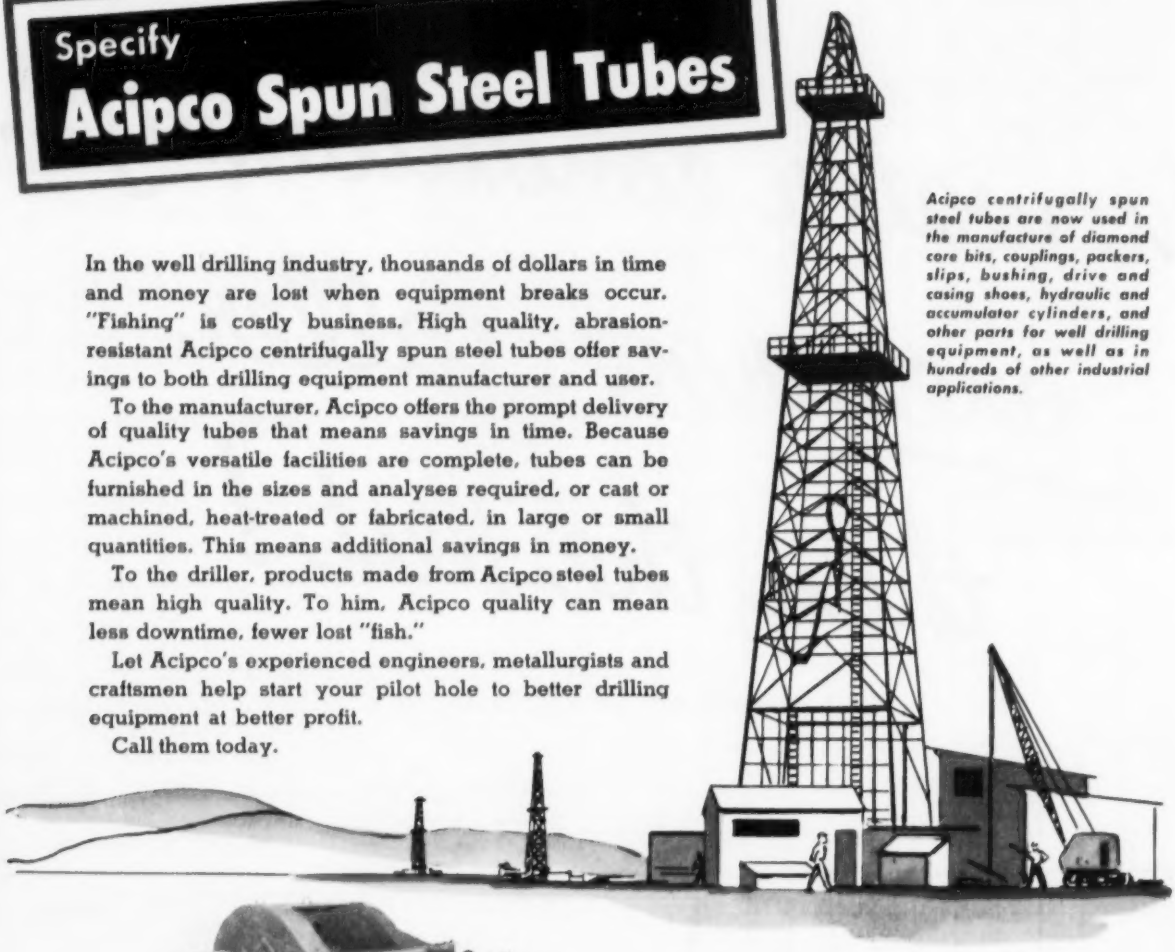
In the well drilling industry, thousands of dollars in time and money are lost when equipment breaks occur. "Fishing" is costly business. High quality, abrasion-resistant Acipco centrifugally spun steel tubes offer savings to both drilling equipment manufacturer and user.

To the manufacturer, Acipco offers the prompt delivery of quality tubes that means savings in time. Because Acipco's versatile facilities are complete, tubes can be furnished in the sizes and analyses required, or cast or machined, heat-treated or fabricated, in large or small quantities. This means additional savings in money.

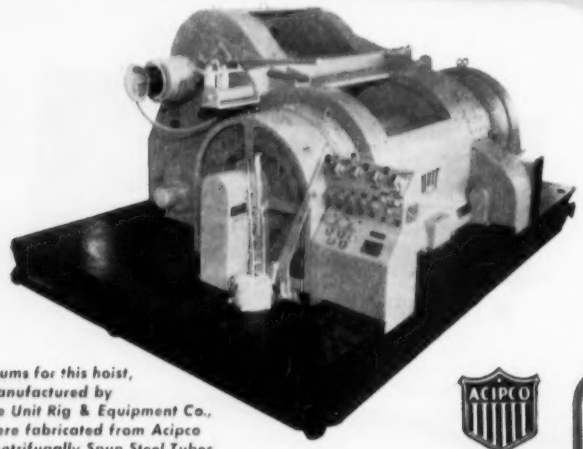
To the driller, products made from Acipco steel tubes mean high quality. To him, Acipco quality can mean less downtime, fewer lost "fish."

Let Acipco's experienced engineers, metallurgists and craftsmen help start your pilot hole to better drilling equipment at better profit.

Call them today.



Acipco centrifugally spun steel tubes are now used in the manufacture of diamond core bits, couplings, packers, slips, bushing, drive and casing shoes, hydraulic and accumulator cylinders, and other parts for well drilling equipment, as well as in hundreds of other industrial applications.



Drums for this hoist, manufactured by the Unit Rig & Equipment Co., were fabricated from Acipco Centrifugally Spun Steel Tubes.

SIZE RANGE: Lengths up to 16' — longer lengths by welding tubes together. OD's from 2.25" to 50"; wall thicknesses from .25" to 4".

ANALYSES: All alloy grades in steel and cast iron, including heat and corrosion resistant stainless steels; plain carbon grades and special non-standard analyses.

FURNISHED: As cast, rough machined, or finish machined, including honing.

AMERICAN CAST IRON PIPE CO.
Special Products Division
BIRMINGHAM 2, ALABAMA

DISTRIBUTORS:

Austin-Hastings Co., Inc.
226 Binney St.
Cambridge 42, Mass.

J. M. Tull Metal & Supply Co.
285 Marietta St., N. W.
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Peter A. Frasse and Co., Inc.
17 Grand St.
New York 13, N. Y.

C. A. Roberts Company
2401 Twenty-fifth Avenue
Franklin Park, Ill.

Lyman Tube & Bearings, Ltd.
920 Ste. Sophie Lane
Montreal 3, Canada

Strong, Carlisle & Hammond Co.
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Ducommun Metals & Supply Co.
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Los Angeles 54, Calif.

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One "Microballoon"* treatment cuts evaporation loss

...a big 80%

Sohio Pipe Line Company has saved an estimated $50,000 worth of crude oil through the use of "Microballoon" spheres. For two full years evaporation has been cut 80 per cent! Yet the complete application paid for itself in a matter of months!

This gathering station of the Tri-State Area located at Mt. Vernon, Ind., includes working and multi-purpose tanks containing Kentucky crude and Illinois crude having a 4 to 6 RVP rating.

"Microballoon" spheres are non-abrading and won't harm tanks, pipes or pumping equipment. For more information, write Bakelite Company, or *Chicago Bridge & Iron Company*, Chicago 4, Illinois.

*Registered trade-mark of The Standard Oil Co. (Ohio)

INSIDE STORY! "Microballoon" spheres float ⅜" deep on surface, forming a perfect vapor-sealing layer for over two years.

BAKELITE COMPANY, *A Division of Union Carbide and Carbon Corporation* UCC 30 East 42nd Street, New York 17, N. Y.

The term BAKELITE and the Trefoil Symbol are registered trade-marks of UCC

A Better Diet for 300 Horses!

As automotive engines reach new horsepower and compression ratio heights, refiners must be ready with super-fuels necessary for their full measure of performance. After all, a diet made for 50 horses just won't do the job for 300.

For more than 40 years, Universal has made available to refiners everywhere new and more economical processes for producing the improved petroleum products needed to meet market requirements. These processes include:

CONTINUOUS THERMAL CRACKING, the first major improvement in refining methods, developed by UOP in the industry's early days.

POLYMERIZATION, a catalytic process developed by UOP and used to convert refinery waste gases into premium quality gasoline.

FLUID CATALYTIC CRACKING, developed to produce greater yields of liquid products and higher octane number gasoline.

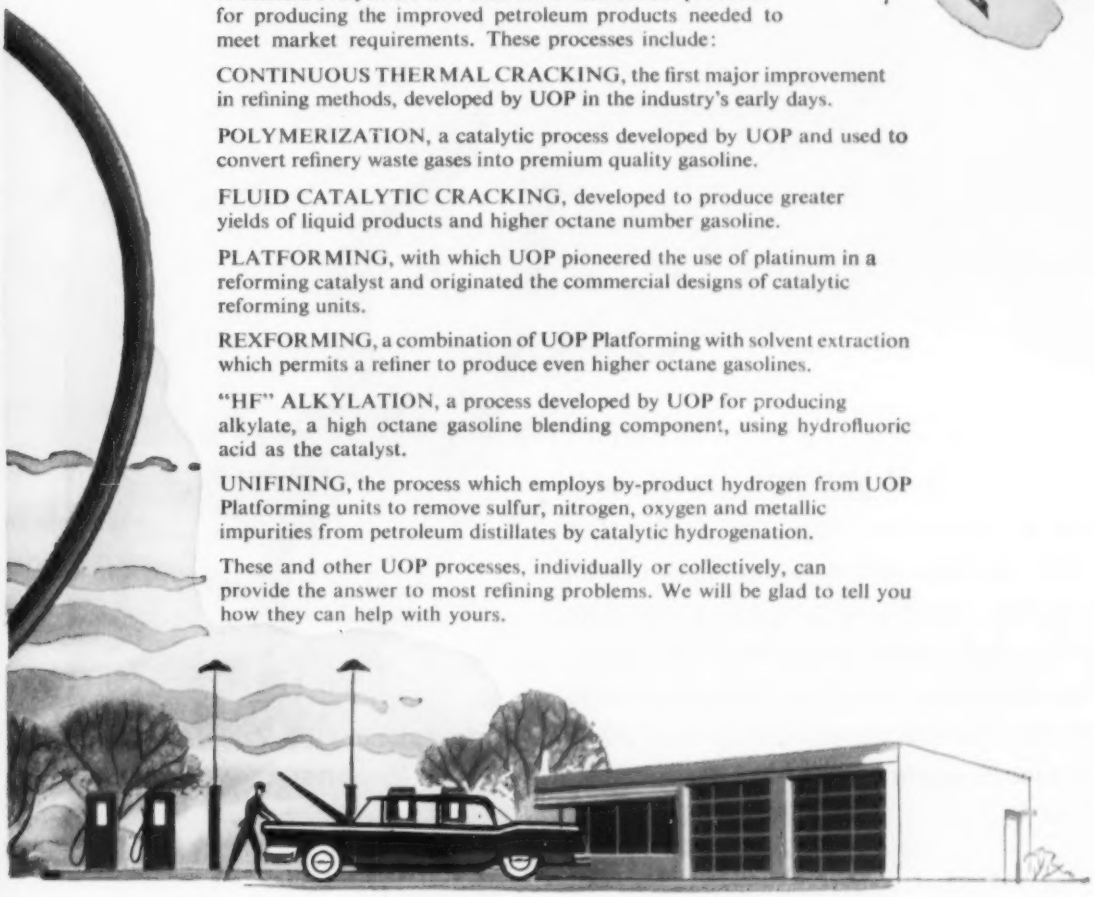
PLATFORMING, with which UOP pioneered the use of platinum in a reforming catalyst and originated the commercial designs of catalytic reforming units.

REXFORMING, a combination of UOP Platforming with solvent extraction which permits a refiner to produce even higher octane gasolines.

"HF" ALKYLATION, a process developed by UOP for producing alkylate, a high octane gasoline blending component, using hydrofluoric acid as the catalyst.

UNIFINING, the process which employs by-product hydrogen from UOP Platforming units to remove sulfur, nitrogen, oxygen and metallic impurities from petroleum distillates by catalytic hydrogenation.

These and other UOP processes, individually or collectively, can provide the answer to most refining problems. We will be glad to tell you how they can help with yours.



UNIVERSAL OIL PRODUCTS COMPANY

30 ALGONQUIN ROAD, DES PLAINES, ILLINOIS, U. S. A.

Forty Years of Leadership in Petroleum Refining Technology

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Practice makes perfect

If you use critical piping, there is a moral for you in this candid shot. Unless you enjoy having headaches and meeting extra costs, assign your next high-temperature, high-pressure piping job to practiced specialists who can take over from the start to finish. Mitchell's 57 years' experience serving power and process plants suggests that you ask us in.

W. K. MITCHELL & CO., INC.
Philadelphia 46, Pa.

WESTPORT JOINT
(PATENTED)

MITCHELL PIPING
SINCE 1899

PIPING FABRICATORS AND CONTRACTORS

Make determinations in 3 to 4 minutes with the

CENCO coulometric mercaptan titrator

Here's a dependable instrument that provides a rapid, routine method of measuring mercaptans and H_2S in hydro-carbons. It's simple to operate . . . requires no standard solutions . . . measures thiols as low as 100 micrograms. From 15 to 20 consecutive analyses can be run without instrument adjustment. Reaction time registers in tenths of seconds directly on the titrator. Average determination time is 3 to 4 minutes depending upon the amount of mercaptan present.

Overall size 12″ x 12″ x 4½″. Operates from 115 volt, 60 cycle power supply. Licensed under patent rights of Standard Oil Company (Indiana).

No. 20930 Cenco Coulometric Titrator complete, **$549.00.**

Ask for Circular No. 1264.

cenco
The most complete line of scientific instruments and laboratory supplies in the world

Central Scientific Company

1732 IRVING PARK ROAD, CHICAGO 13, ILLINOIS

BRANCHES AND OFFICES—CHICAGO • NEWARK • BOSTON • BIRMINGHAM • DETROIT • SAN FRANCISCO • SANTA CLARA • LOS ANGELES • REFINERY SUPPLY COMPANY—TULSA • HOUSTON
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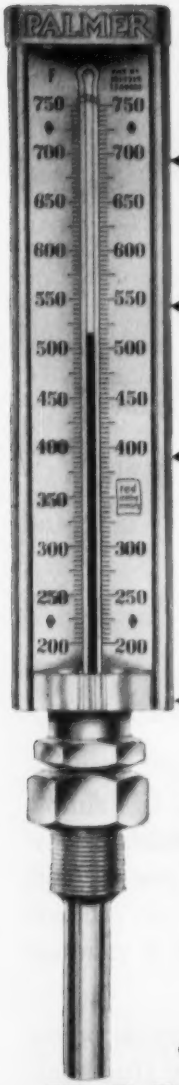
Today's Modern Industry
Demands a Modern Thermometer

PALMER

RED-READING MERCURY THERMOMETERS



Red-Reading Mercury

Extruded Brass Case

Chrome Finish

Ranges −40 to 950°F or Equivalent in °C

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Consult your Classified Directory

PALMER

THERMOMETERS, INC.
Mfrs. of Industrial Laboratory, Recording and Dial Thermometers
Cincinnati 12, O.

The Mail Box . . .

Matter of Budget

To The Editor:

Your article entitled "Here's a Good Way to Premix Treating Chemicals and Water" ("How To Do It," April, 1956) may well have covered a stop-gap method of accomplishing the results outlined with available equipment—I believe this is the case.

I feel very strongly however that unless corrected it will tend to create the impression that it's an economical means of treating *all* small and moderate boilers . . . This would appear to be a rather difficult approach to a relatively simple problem.

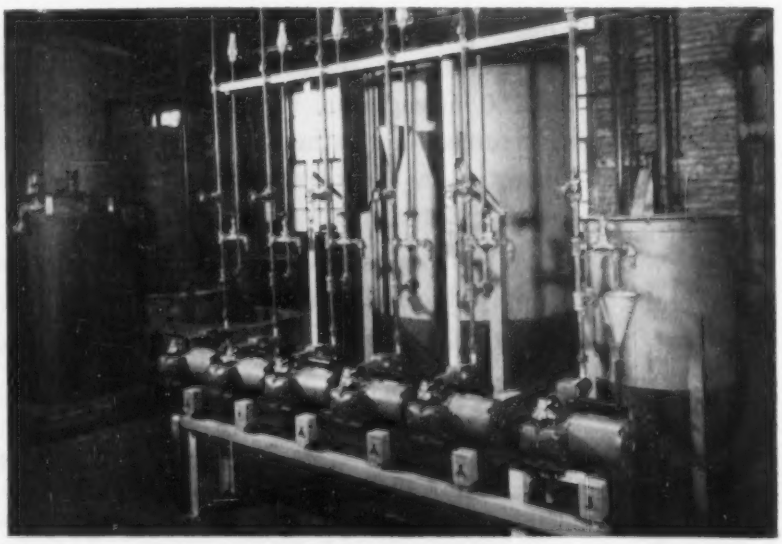
The accompanying photo illustrates a typical installation of inexpensive proportioning pumps especially designed for this service. By adjusting the stroke length to the desired settings it is possible to predetermine the exact amount of chemical which the pump will deliver over a given period of time. The pumps illustrated are used for both internal and external (boiler) treatment. Those handling the internal treatment (five pumps) inject treating chemicals direct to the boiler steam generating drums . . . the sixth pump injects sulfite to the main feed water storage tank. All (these) pumps have an adjustable capacity of from 0.5 to 5.0 gph and will operate at pressures up to 650 psig.

This system enjoys a number of advantages over the premixing method employing the use of relatively large mixing and retention tanks. The premixing method requires the use of a pump to move the chemicals from the small mixing tank to the large retention tanks. By injecting directly to the boiler and bypassing the large tanks, tankage costs can be materially decreased. In plants with existing tanks there are generally more requirements for tank storage than available tankage so that bypassing these tanks altogether can very nicely free two rather large—and expensive—tanks for process or storage use. When installing a new system the savings on one tank can more than pay for several small proportioning pumps.

The use of a steam lance for mixing chemicals is to be discouraged. Some of the phosphates at high temperatures have a decided tendency to go over to mono-sodium-ortho-phosphate or phosphoric acid. Rapid corrosion of feeding equipment and piping follows unless the equipment is designed to withstand this type of attack.

Other compounds employ the use of dispersers. The use of a steam lance has a distinct tendency to "burn" or carbonize these dispersers. This results invariably in the carbonized materials plugging pumps, valves and water level controls.

. . . The use of air to agitate the chemicals in the large tank can undoubtedly lead to operational difficulties. The practice of introducing air either through a pump or by a compressed air lance will result in excessive dissolved oxygen being introduced to the boiler. If any sulfite has



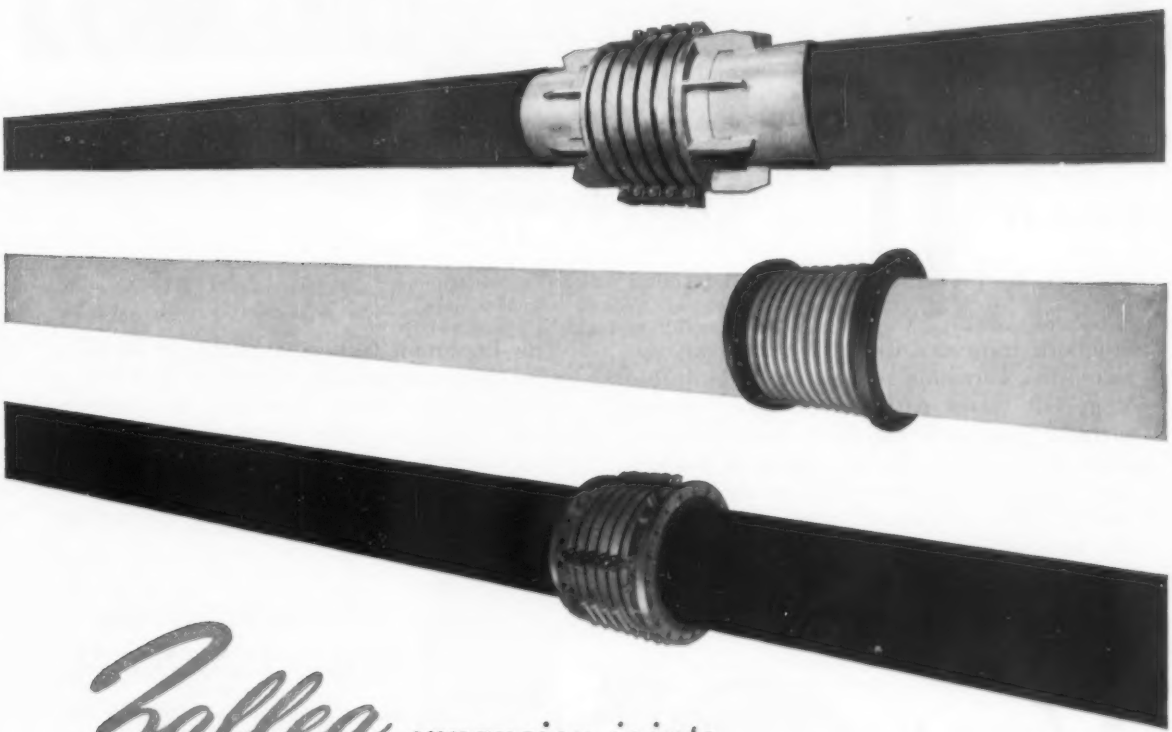
Typical installation of proportioning pumps.

For more data on advertised products, use Readers' Service Cards, last page.

The true cost of an expansion joint is not the figure on the manufacturer's price tag. Many factors enter into any such cost determination. For example, an expansion joint that fails just when it shouldn't could wreck a plant and cost a small fortune. And, assuming equal first-cost of any two competitive manufacturers' designs, one that stands up twice as long as the other . . . costs only half as much on a unit-time basis. So, one really shouldn't count on "price" as a measure of value.

But here is one thing you can count on. Every single expansion joint in the Zallea line is designed and built to assure maximum reliability —and top value for your dollar. This is no empty boast, but a fact that can be confirmed for you by figures.

So, whenever you have problems—or needs—relating to expansion joints, don't fail to get in touch with Zallea. Write today for Bulletin 351, containing condensed descriptions of the many types. There is a Zallea joint for every requirement.



Zallea *expansion joints*

ZALLEA BROTHERS, 890 LOCUST STREET, WILMINGTON 99, DELAWARE

World's Largest Manufacturers of Expansion Joints

For more data on advertised products, use Readers' Service Cards, last page.

Hard faced WITH STELLITE to resist seat wear

...at no extra cost!

GP Globe Valve-Series 800

Stubborn resistance to valve seat wear, due to erosion, corrosion and galling, is built into Vogt GP valves with Stellite faced seating surfaces used in conjunction with hardened discs and wedges. By an exclusive method, hard facing alloys are welded to the integral seat of globe and angle valve bodies and to the removable stainless steel seat rings of gate valves.

This important feature, available at no extra cost, assures operation economies and longer valve life. A catalog describing the complete General Purpose line of valves in sizes 1/4" to 2" will be sent on request.

Adv. No. 3 in a series describing the features of Vogt GP valves.

Write For Your FREE COPY of Supplement No. 1 to Catalog F-9 Address Dept. **24-FPR**

HENRY VOGT MACHINE CO.
P. O. Box 1918 • Louisville 1, Kentucky

SALES OFFICES:
New York, Philadelphia, Cleveland, Chicago, St. Louis, Charleston, W. Va., Cincinnati, Dallas, San Francisco

Vogt GENERAL PURPOSE GP Vogt FOR BETTER VALVES

DROP FORGED STEEL

VALVES

The Mail Box . . . .

been included in the premixing the affects of this chemical will be largely nullified by the oxygen pick up.

The most economical, safe and reliable boiler system is through the use of a small, inexpensive proportioning pump—a pump designed and manufactured for this express purpose.

E. R. Franklin,
Project Engineer
Proportioneers, Inc.
Providence, R. I.

Editor's Note: Mr. Franklin's is a better treating method. For a long range application where tankage is in short supply or unavailable, the method described in the "How To Do It" department would probably not be used. However, budget requests for new equipment in some of the smaller plants or in older facilities of the larger plants are not always approved by management. For short-range economics, the stop-gap method, as suggested by Mr. Franklin, is often used. "How To Do It" items are not always intended to give the best, but rather a possible position to a problem.

Too Much Condensed

To the Editor:

We certainly appreciate your printing our API paper "How Richfield Plans to Combat High-Temperature Sulfide Corrosion in its New Catalytic Reformer" and recognizing its value to the industry (PR, May, pages 146-149). Condensation by omission of parts weakened the first section of the paper, and in several instances caused incorrect statements. For example:

1. Column 1, page 146, line 6: "in these media" reflects thermal and catalytic cracking units and not catalytic reformer units as implied.
2. Column 1, page 146, line 12: the word "not" should be omitted.
3. Figure 4 should be labelled: "Temperature 950 F., Pressure over 400 psig;" and Figure 5: "Temperature 780 F., Pressure over 400 psig."

We have a limited number of API preprints and will be happy to mail them to your readers on request.

B. W. Neumaier
C. M. Schillmoller
Richfield Oil Corporation
Wilmington, Calif.

Editor's Note: Authors, Neumaier and Schillmoller are right. The red pencil went awry.

... make every step a safe step
BLAW-KNOX ELECTROFORGED® STEEL GRATING and STAIR TREADS

Outdoors or indoors, throughout your plant, you can provide safe walking conditions on catwalks, stair treads, walkways, platforms and floors. For Blaw-Knox Electroforged Steel Grating brings you these exclusive features:

1. rigid one-piece construction—easy to install
2. non-slip twisted crossbar—for safe footing
3. three types of bearing bars
   - square bars—for smoothest walking surface
   - knurled bars (Furro-Grip)—for extra safety plus relatively smooth walking surface
   - serrated bars—for maximum safety under extremely hazardous skid conditions
4. no sharp corners to clog—self-cleaning
5. all surfaces accessible—easy to paint
6. maximum open area—for light and ventilation

Write for your copy of new Bulletin No. 2486
—or send dimensional sketch for quotation.

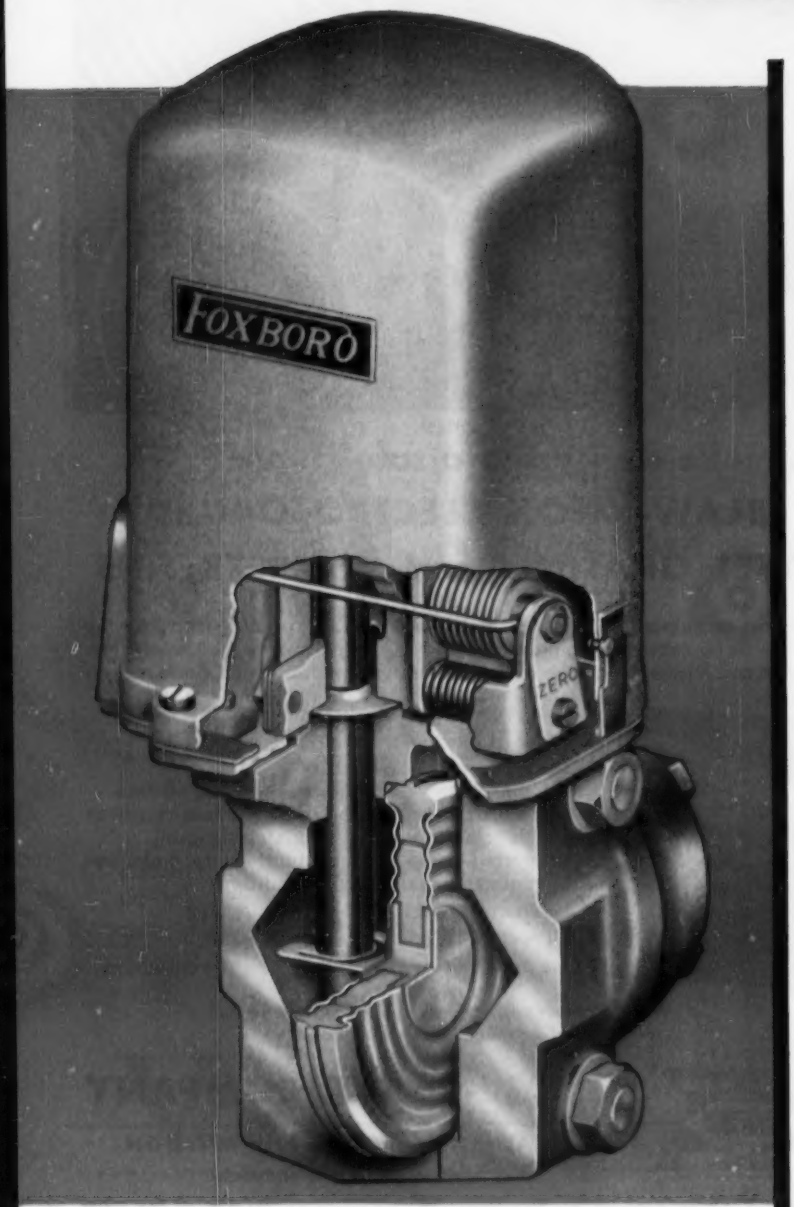
50th Anniversary BLAW-KNOX 1906-1956

BLAW-KNOX COMPANY
BLAW-KNOX EQUIPMENT DIVISION
Pittsburgh 38, Pennsylvania

GRATING APPLICATIONS: floors • platforms • walkways • catwalks • stair treads • fan guards • shelving • and many other uses, both outdoors and indoors, for versatile steel grating

For more data on advertised products, use Readers' Service Cards, last page.

ONLY the Type 13A d/p has these 6 advanced-



- **Positive Overrange Protection** up to full 1500 lb. rating
- **Fully Adjustable Ranges . . .** 0-20″ to 0-80″ and 0-50″ to 0-250″ H_2O differential
- **Automatic Internal Damping** . . . fast, *stable* measurement
- **Simplicity** . . . easiest, lowest cost installation, least maintenance
- **Convenient Zero Adjustment** . . . external — no need to remove weatherproof cover
- **Highest Sustained Accuracy** . . . even under extreme operating and ambient conditions

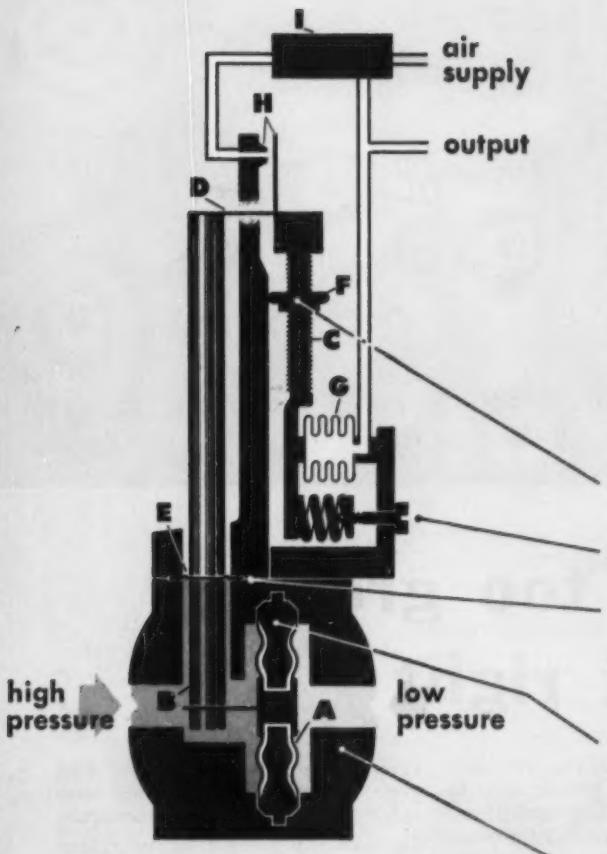
With these basic features, plus many other technical refinements throughout, the new Type 13A d/p Cell* Transmitter surpasses all previous records in performance . . . economy . . . convenience. For the complete story and a demonstration, call your nearest Foxboro representative. Write for new Bulletin 13-11. **The Foxboro Company, 746 Neponset Ave., Foxboro, Mass., U.S.A.** Factories in the United States, Canada and England.

*Reg. U. S. Pat. Off.

More Foxboro flow transmitters are in use by the process industries than all other makes combined!

Cell Flow Transmitter

design features...



How It Works . . .

An increase in differential pressure across Twin-Diaphragm Capsule (A) exerts force to right on force bar (B). Elgiloy® diaphragm seal (E) acts as fulcrum. Force to left at top of bar (B) causes flapper to approach nozzle at (H). Resulting increase in nozzle pressure is amplified by relay (I). This pressure is sent to feedback bellows (G) which develops force to counterbalance the differential pressure on capsule (A). The 3-15 psi output signal from relay (I), always precisely proportional to differential pressure, is transmitted to remote recording or controlling instrument.

Range Wheel is continuously and easily adjustable for entire range whether 0-20" to 0-80" or 0-50" to 0-250" H_2O.

Easy-access screw adjustment permits field "zeroing" without removing weatherproof cover.

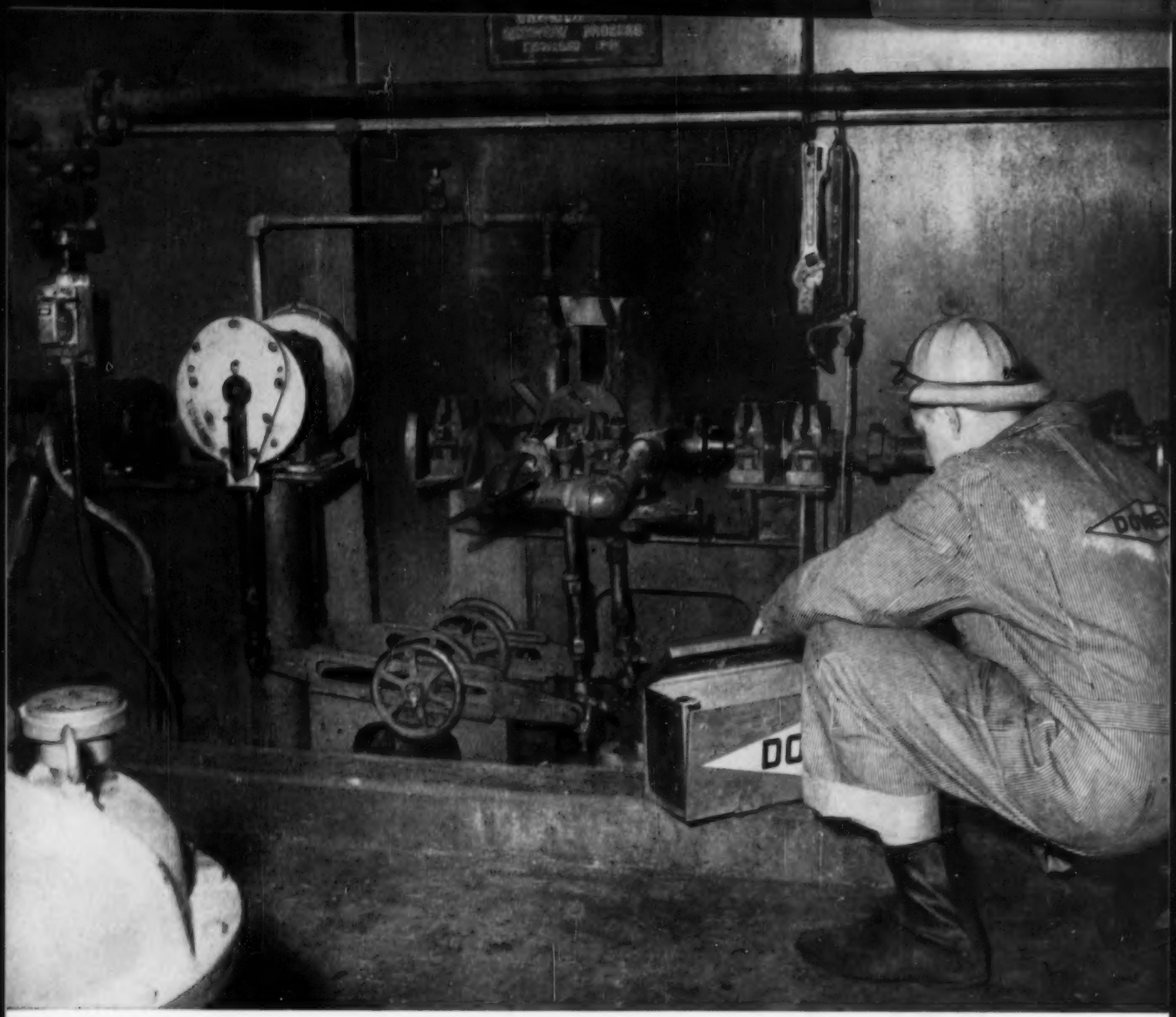
Elgiloy® stainless alloy diaphragm seal assures a corrosion-resistant, frictionless, positive pivot point. Instrument is constructed in 3 basic units — body, transmitter, and air relay block — eliminating all possibility of errors produced by piping stresses.

Silicone-filled Twin-Diaphragm Capsule filters out flow disturbances ("noise") at measurement source . . . without loss of speed of response. Precisely matched surfaces of diaphragms and capsule core provide "stops" which give positive overrange protection in both directions.

Rugged forged body, optionally Type 316 S.S. or carbon steel, gives greatest strength with least weight . . . ultra-compact design permits low cost mounting from flange taps.

FOXBORO
Reg. U.S. Pat. Off.

First in Flow Instrumentation



The risk is too great —clean it right

You don't take risks when men, equipment, and lost production time are involved. That's why more and more companies are investigating the methods and firms used in their chemical cleaning. They know it's work for experts.

What are they concerned about?

First, they want to know they are getting the benefits of experience. These benefits include less downtime and more thorough cleaning. Dowell has this experience with over 15 years and 10,000 boilers alone to their credit. In saving downtime, Dowell often cleans equipment while it is in operation.

Next, these companies want to be sure their men and equipment have the greatest possible protection. Dowell excels here, too. For safety is foremost in the Dowell engineer's mind. Thoroughly trained, he uses only the latest safety methods and equipment. He works closely with your safety personnel to establish safest possible working procedures.

Be sure you are getting maximum results with maximum protection in your chemical cleaning.

Call the Dowell office near you. Dowell engineers are ready to discuss and help you with your cleaning problems any time, at no obligation. Or write Dowell Incorporated, Tulsa 1, Oklahoma, Dept. F-31.

chemical cleaning service for industry **DOWELL**

A SERVICE SUBSIDIARY OF THE DOW CHEMICAL COMPANY

A Quick Look at the Industry THIS MONTH

All Industry Outlook . . .

Skidding stock market prices—mass lay-offs in auto industry—rising inventories are snagging '56 business boom. Experts say this is only temporary. After excess inventories are used up or sold off, business will gain new impetus and shoot ahead to set new records.

N.A.M. says look out for union mergers—they are new force for inflation. Reason: Unregulated power of labor unions results in "a tendency for wage rates to grow without any definite or normal relationship to market conditions."

—•—

Gasoline Demand to Set New Records . . .

Gasoline's future looks bright demand-wise. Summer demand expected to show 4.7 percent jump over '55 to nearly 4.1 million barrels daily.

Demand for all oil products will reach new daily peak of 8.6 million barrels by October—4.9 percent above same period in '55.

Fly in the ointment: Gasoline stocks are up more than 8 percent over '55, despite recent cutbacks in runs to stills.

—•—

Postings on Octane Race . . .

Four majors are knocking on 100 octane's door and the rest will soon follow suit. Sun with its special "five-grade" pump started ball rolling. Now Esso and Humble announce "third" grade of super fuel. Socony Mobil is marketing "Mobil Gas-R" with high enough octane to eliminate engine knocks in most cars—at regular prices.

Best bet on 100-plus octane scale is that present scale for under 100 will be extended. Group pushing this is getting strong opposition from some refiners who favor changing to avgas performance numbers above and below 100. Decision may come at June meeting of ASTM and CRC.

Despite feeling that a decision is long overdue on this problem, most refiners agree that the bigger problem is improving precision of octane number determinations.

Meanwhile, announcement of three isomerization processes (Isomerate, Pentafining, Penex) signal trend in gasoline upgrading in direction of war time avgas methods, instead of severe catalytic reforming. Alkylation, very active in past year, is also part of the trend.

—•—

Benzene With A Red Tint . . .

U. S. benzene production set new records in '55. We also imported about 11 percent (32.1 million gallons) of our total production. 87 percent of the imported benzene came from **Poland** and **Russia.**

—•—

No Fear for Fuel . . .

By year 2000 all likely sources of hydro-electric power will have been exploited; U. S. capacity to produce oil, gas and coal will have been strained to limit—so says A.E.C. Commissioner Libby. However, we needn't fear for fuel. Present known sources of uranium are more than 20 times the known resources of oil, coal and gas combined. (What about 900 billion barrels of shale oil up Colorado way?)

A Quick Look at the Industry (continued)

Opposition to Crude Price Hike . . .

"Big" and "little" don't agree on logic of crude price increase. Jersey Standard says supply-demand ratio won't support crude price hike—that inventories are adequate, crude is in good supply and productive capacity is ample.

TIPRO tells a different story: In asking purchasers to increase crude prices 60 cents a barrel, Texas independents say producers lost $150 million last year—that exploration and production costs far exceeded $12 billion reported for '55.

—•—

Steel Price Hike Will Set New Marks . . .

Impending wage boosts, huge expansion plans are big arguing points in steel's talk of biggest price increase—$15 a ton—in its history. Economists say no—such a big price boost is unnecessary, would fan inflation flames. They say steel could finance expansion and higher wages with present profits.

No matter what the argument, price jump will come after labor settlement this summer. However, final asking price will be $10-$12 a ton over present costs, not $15.

—•—

Jet Fuel From Coal? . . .

If Army and Navy's "Zip"—a new "secret" fuel, said to be sans oil or natural gas—lives up to claims, it may have long range effects on oil industry. Congressional sources say it is made from chemical base, of which coal is main ingredient.

Armed forces are so happy with Zip's low weight—high energy qualities, they are pressing Congress for funds to build two Zip plants. Present threat to oil: Fuel for jets.

Jet fuel production is expected to increase 150 percent during next four years. Even so, aviation gasoline volume will hold at present level until 1960, at least. Reason: 546 gasoline engine aircraft are on order now compared with 745 jets.

—•—

Trends in Synthetics . . .

Free from government reins only a year, synthetic rubber has upped production 50 percent—plans $116 million expansion program—and has kept prices stable. Expansion is needed to reach 1.6 million long tons in '59 compared with 1.48 million this year.

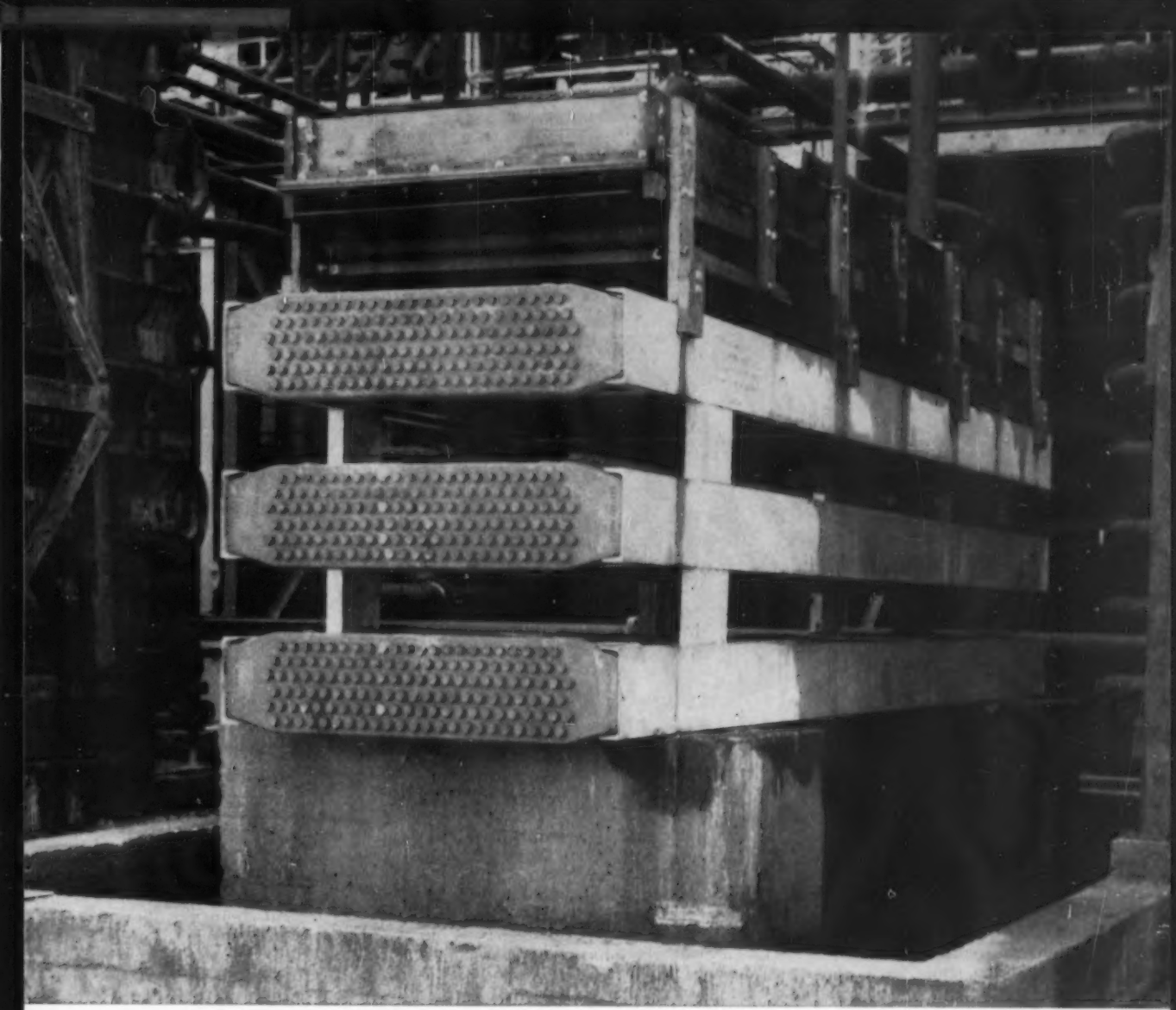
Canada's investment in petrochemical facilities has passed $300 million mark—a 15-fold increase since World War II. New plants now being designed or under construction will jump investment another $50 million.

In six years, plastic pipe has sprouted from a "pup" doing only $5 million in sales to a "mastiff" topping $45 million in '55—and expects to total $60 million this year. Predictions are plastic pipe will approach $200 million in sales by '60.

—•—

New Oil Fields Show Promise . . .

The world's deepest oil production was discovered in April by Richardson & Bass, John W. Mecom, and Freeport Sulphur Co. in Plaquemines Parish, South Louisiana. New depth champion produces 135 barrels of 43-gravity oil daily. None of the other 85 new oil fields opened during the month had much claim to fame, but several appeared to be fairly significant. They were: Humble's discovery in San Juan County, New Mexico, producing 370 barrels of 44-gravity oil a day; Ralph Lowe's strike in Lea County, of the same state, good for 2600 barrels of 46-gravity; Texaco's wildcat in Ochiltree County, Texas Panhandle, flowing 635 barrels of 43-gravity oil; and a 410-barrel, 26-gravity, find by Stanolind in Park County, Wyoming.



less slime . . . more heat transfer with Stainless Steel tubes

Carbon steel tubes were previously used in this copper solution cooler, but they built up slime and scale rapidly. This reduced the heat transfer coefficient, and made it necessary to clean tubes frequently.

So the tubes were replaced with type 304 Stainless Steel. Cleaning has been practically eliminated. The tubes are expected to last indefinitely, and the increased heat transfer has reduced the output feed stock temperature by a good ten degrees.

Here is a Stainless Steel feature that is sometimes overlooked: the smooth, dense surface repels filth and contamination. In heat exchangers, this results in lower fuel costs and maintenance costs. As a bonus, you have the great corrosion resistance and strength that make Stainless Steel so popular in modern refineries. But be sure of service-tested quality; specify USS Stainless Steel.

UNITED STATES STEEL CORPORATION, PITTSBURGH · AMERICAN STEEL & WIRE DIVISION, CLEVELAND
COLUMBIA-GENEVA STEEL DIVISION, SAN FRANCISCO · NATIONAL TUBE DIVISION, PITTSBURGH
TENNESSEE COAL & IRON DIVISION, FAIRFIELD, ALA.
UNITED STATES STEEL SUPPLY DIVISION, WAREHOUSE DISTRIBUTORS
UNITED STATES STEEL EXPORT COMPANY, NEW YORK

USS STAINLESS STEEL

SHEETS · STRIP · PLATES
BARS · BILLETS
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PIPE · TUBES · WIRE
SPECIAL SECTIONS

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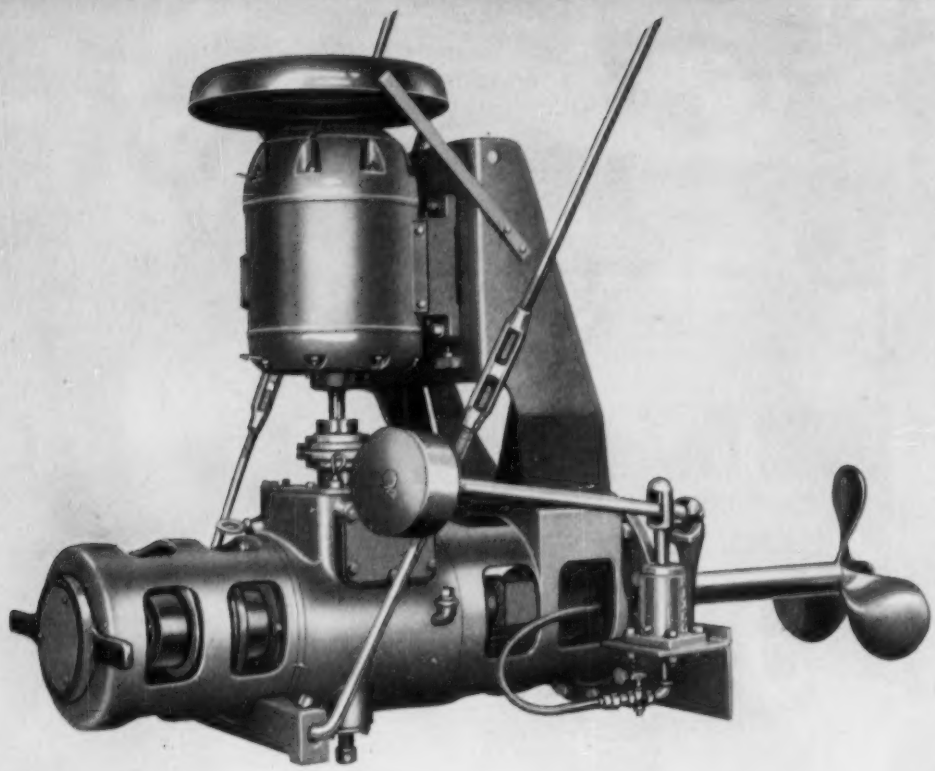
UNITED STATES STEEL



This is the mixer **you** *helped design*

You wanted a big-tank mixer that would mix fluids fast—to complete uniformity. But that wasn't nearly enough.

You wanted a mixer you could *forget.* A mixer that would run year in, year out, with the barest routine attention.

You first told us about the need for a shaft bearing that wouldn't have to run submerged in the tank liquid.

That's when we put *ball bearings* in LIGHTNIN Mixers—and moved the bearings back *out* of the tank, away from grit and trouble.

You didn't want to be bothered aligning the mixer when you put it on the tank. So we housed the LIGHTNIN in three rigid castings, joined with concentric rabbet fit that can *never* get out of line, no matter what.

You wanted the gears protected from unusual shock loads—as might happen if the propeller whacked a ladder or other obstruction in the tank. We found the answer for you—in *hollow-quill drive* that isolates the gears from the shaft, protects your investment with a flexible coupling between shaft and gearing.

You wanted to repack the mixer stuffing box quickly—without having to figure out where to put 180,000 barrels of product while repacking. We developed the LIGHTNIN shutoff device that pulls the shaft back like a valve stem, sealing the tank so you don't lose even a pint of product. And we put *handles* on the shutoff because your maintenance men like it that way—out in the open, easy to get at.

But then you got to wondering about the stuffing box itself. Would a rotary mechanical seal do the job better? What about *replacing* the seal, if it ever wore out?

This time, your quest for something a little better *really* paid off. Now you can get a LIGHTNIN Mixer that runs for years *without repacking or adjustment.* No stuffing box. No leakage around the tank. And should the LIGHTNIN Seal ever wear out, you can replace it in *minutes.* No dismantling. No unhitching the mixer from the tank. *No need for special skill.* It's saving oil companies thousands of dollars a year in upkeep!

Thanks to your telling us what you like—and don't like—in a mixer, hundreds of LIGHTNINS have been in service for more than 25 years. More than ever, today's LIGHTNINS meet your needs realistically, in every respect. More reasons than ever before to put LIGHTNINS on *your* big tanks.

For quick, knowing help on fluid mixing, call your LIGHTNIN representative. (He's in Refinery Catalog.) Or write us.

"Lightnin® Mixers"

MIXCO fluid mixing specialists

CUT MIXER MAINTENANCE 60% with this new LIGHTNIN cartridge-type rotary seal—optional with LIGHTNIN Mixers. It runs for years without adjustment—and slides off the shaft for fast, easy replacement if ever necessary.

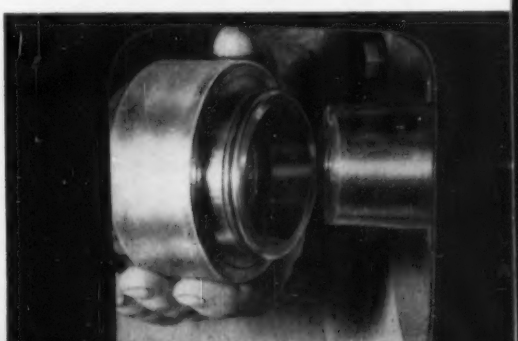
FOR LATEST MIXING INFORMATION and full description of LIGHTNIN Mixers, send for these helpful bulletins:

- ☐ B-102 Top or bottom entering; turbine, paddle, and propeller types: 1 to 500 HP
- ☐ B-103 Top entering; propeller types: ¼ to 3 HP
- ☐ B-108 Portable: ⅛ to 3 HP
- ☐ B-104 Side entering: 1 to 25 HP
- ☐ B-112 Laboratory and small-batch production types
- ☐ B-110 Condensed catalog showing all types
- ☐ B-111 Quick-change rotary mechanical seals for pressure and vacuum mixing
- ☐ B-107 Data sheet for figuring mixer requirements

Check, clip, and mail with your name, title, company address to:

MIXING EQUIPMENT Co., Inc. 164-f Mt. Read Blvd., Rochester 11, N. Y.

In Canada: Greey Mixing Equipment, Ltd., Toronto 10, Ont.



"Those who know us best like us best," so—

Let the Public Know!

The public "thinks we are a bunch of rich, overbearing braggarts with a tax gimmick."

These acid words were spoken by a man who should know—Jake L. Hamon, chairman of the American Petroleum Institute. That such a thought should even enter an oil leader's mind, let alone be printed, forms the basis for one of the most glaring paradoxes on the American scene.

The public can hardly deny that it took more—much more than braggarts with a tax gimmick to play a principal role in winning two world wars—to lift this country from mediocrity to unquestioned world leadership—to make American's transportation system, farm productivity, heating methods and production lines the finest in the world.

The public can hardly deny that—within an average life span—men with sheer guts and a willingness to lose everything they owned, transformed oil into a $40 billion industry, second only to agriculture.

Nor can anyone deny that in 1955 the oil industry:

- Was composed mostly of small companies competing sharply with each other.
- Paid more federal taxes than any other industry (nearly $5.5 billion, excluding employe income taxes).
- Averaged less than 10 percent on investment and less than 4 percent net profit, almost exactly the same as for industry as a whole.
- Paid the second highest wages and salaries in the nation.
- Offered employe benefits excelled by few—if any—other industries.
- Had one of the lowest labor turnover records of any industry.
- Had fewer strikes than most industries.
- Topped most industries in contributions to science, technology and education.

Yet at the same time the price of oil and its products has increased so slightly as to be almost indiscernible compared with other commodities.

The public cannot deny any of these true facts—nor can they confirm them. Why?

Because the public doesn't know!

The public doesn't know because the oil industry expends too much of its public relations effort either talking to itself or hiding behind a cloak of righteous conservatism.

The millions of words passed from oil leaders and trade publications to other oil men expounding the need for public relations—the risks oil men take—how outstanding the industry is, creates not one ounce of public understanding or good will for the industry.

The oil industry's conservative "open the door a peek" attitude toward the press, i.e., releases telling about a new wildcat being drilled in some county to attempt to test some formation and that the project is contracted for so many feet in depth, *without the slightest mention of estimated cost*—expansion releases describing new construction in "square feet" *with no mention of estimated cost*. Such actions of intentional omission does not create better understanding of the industry.

No wonder the newspapers and critics yell "propaganda!" when oil attempts to explain its side in a crisis. No wonder the public eats up sensational news stories about the antics of a minute few addle-brained "Johnny come lately" millionaires who plague the industry. No wonder the public thinks of oil in terms of these few "braggarts."

These are big reasons why the oil industry, although it has done as much or more than any other industry for the American public, can find so few friends when the chips are down. This is the glaring paradox.

This absurd situation can be changed with but little effort. In fact, some—too few—oil companies have already pulled their heads out of the sands of conservatism.

An excellent example is Tidewater Oil's policy of showing the budgeted price for wildcats when they are announced to the press. Another is Imperial Oil's audio-visual program which gives the true facts about the company—and the industry—to each employe.

As Imperial demonstrates, publicity alone will not create public favor. Every employe in the industry

---

"The fight the oil industry must make to regain public confidence after the Harris-Fulbright incident overshadows all of the many economic problems we face.

"Industry's public relations have so deteriorated as to leave question whether we are going to have free enterprise or a politically controlled economy.

"Getting back into public favor will require intelligent planning and a program of action to dramatize the outstanding accomplishments of the American oil industry."

—Walter S. Hallman, President
Plymouth Oil Company

ADDITIVES	GULF COAST		MID-CONTINENT		WEST COAST	
	$ Saving	% Saving	$ Saving	% Saving	$ Saving	% Saving
Du Pont Antioxidant No. 22	$2,250	6.7%	$2,250	6.7%	$2,400	7.0%
Du Pont Fuel Oil Additive No. 2	$1,680	8.3%	$1,710	8.4%	$1,850	8.9%
Du Pont Lube Oil Additives	$1,830	12.0%	$1,860	12.0%	$2,000	12.5%

Shown above are nine typical situations—three locations, three additives. They illustrate how substantial sums can be saved when you order Du Pont additives in 4,000-gallon tank-car lots. The saving is over the costs of the same quantities in less than carload lots, in drums. The total savings shown reflect lower product cost and lower freight rates.

Four-figure savings are yours each time you order a Du Pont additive by the tank car

If you have been buying your additives in drums—either in carload or less than carload quantities—it will pay you to investigate the savings in delivered cost that are possible by ordering in tank-car lots.

For example . . .

The above chart shows how refiners in three areas can save from $1,680 to $2,400 simply by ordering a Du Pont additive by the 4,000-gallon tank car instead of equal quantities in partial car shipments in drums. These figures are, of course, based on the freight rates for only three locations; savings will vary somewhat for other receiving points. However, the saving will be decidedly worthwhile anywhere . . . for any one or more of the products listed.

How much can you save?

To answer that question for you, one of our nearby representatives will be glad to call at your refinery, study your freight rates and inventory patterns. He will then determine the most convenient handling method for you and figure the exact saving you can make. Phone, write, or wire us . . . today.

DU PONT
REG. U.S. PAT. OFF.
Better Things for Better Living . . . through Chemistry

Petroleum Chemicals

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must be an *informed* ambassador of good will.

These are examples that might well be followed by the entire industry. But these are not enough, many new examples must be created. Opening all doors to the public and telling oil's story to people outside the industry ranks would be good places to start.

Those who know us best will like us best.

The oil industry has a great story to tell. Let's tell it to the public—to employes—to dealers—to every individual who will listen.

Gasoline Output Could Be Shaved

AFTER U. S. refineries reduced the amounts of gasoline manufactured during April, they came back with a build-up in the first three weeks of May. Due to this output hike, motor fuel supplies were being drawn off at a somewhat lower rate than is customary for the period.

Despite record gasoline consumption for this season of the year, it appeared that refiners were still making too much product. This was resulting from increased refinery crude runs and boosted gasoline cuts, and preventing existing supplies from being consumed fast enough.

Otherwise, the industry's inventories of crude oil and other refined products were in fairly good balance with requirements, and operating levels indicated they would likely improve in coming weeks.

The net decline in gasoline stocks amounted to only three million barrels from the end of April to May 18, while the corresponding period of 1955 saw storage dropped about five million barrels. Consequently, the nation's inventory on May 18 was slightly more than 16 million barrels greater than it had been on the same date a year earlier. At the beginning of May, stocks had been but 13½ million barrels ahead of year-before levels.

Daily crude runs at U. S. plants showed a hefty gain in early May over April, 1956.

A Contrast In Rubber

THOSE WHO flash the banners for more government control of industry should take a long look at the way synthetic rubber has fared after eight months of private ownership.

With but few reservations, the picture is much brighter than it ever was under government control. Competition has stepped up and product quality has improved. The ten relatively strong GR-S producers and nine major butadiene manufacturers have lost little time in opening new markets at home and abroad.

First reports from the attorney general on synthetic rubber competition show that most of the small rubber fabricators have received a fair share of synthetic rubber at fair prices. Less than 10 percent of the companies interviewed expressed any dissatisfaction with the industry's performance under private ownership.

In fact, a significant number of small companies reported that private enterprise is far superior to government operation.

The buyers are expressing pleasure at the new buying methods used under private enterprise—no longer must a buyer pay in advance and order 90 days ahead of delivery; now the orders are filled immediately and on open account.

Personal dealing with the producers and access to the technical staffs of synthetic rubber manufacturers has proved to be an added benefit for the small buyers.

It was also found that the quality of GR-S has generally improved during the short period of private ownership.

However, as the attorney general points out, there are some factors in the industry which may impede the development of all out competition, i.e., the tendency on the part of producers to continue the pattern of product specialization which existed under Government ownership. This pattern of production, if continued, would tend to insulate certain areas of production from the competition that normally would be expected to develop in a competitive industry.

The survey also revealed that there is a tendency toward price inflexibility in the synthetic rubber industry similar to that under government monopoly. The lack of sensitivity of GR-S prices during the past eight months was cited as an example.

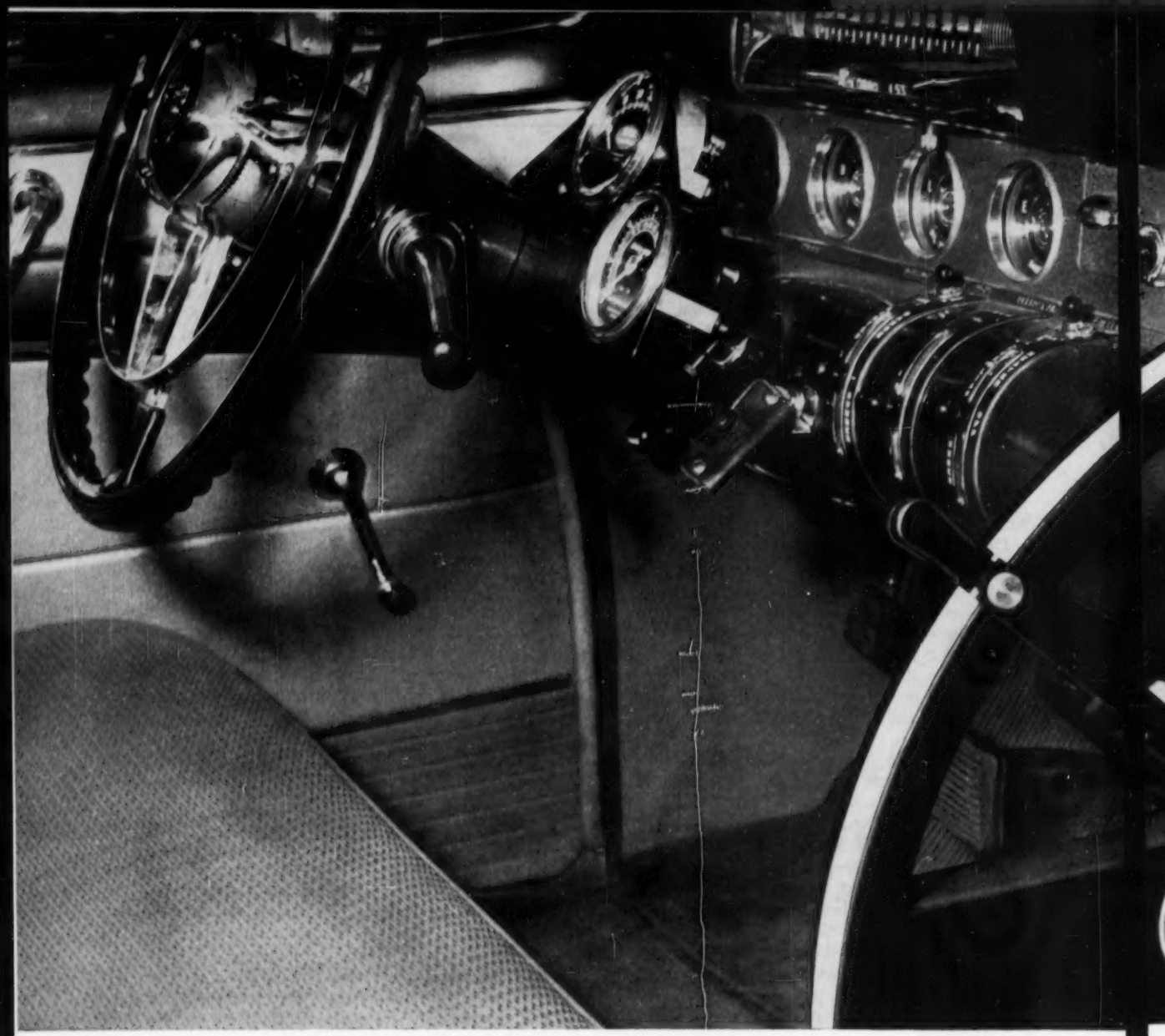
Conclusions to be made from the attorney general's report are obvious: Eight months may be a short time to predict a trend in product specialization or in prices. Give the industry enough time to chart its course and the profit incentive of free enterprise will correct any and all lingering influences of government monopoly.

What's in a Name?

THE PETROLEUM REFINER has noted that hydrogen peroxide, "that time-honored inorganic chemical," has joined sulfur and other time-honored compounds and elements as a petrochemical through its production from isopropyl alcohol. Certain sources have challenged this union—they say the petrochemical industry has gone too far.

What's in a name? Many have asked but few have had the temerity to answer. Shakespeare wrote "That which we call a rose by any other name would smell as sweet" while Humpty Dumpty in *Through the Looking Glass* took a broader view," "When *I* use a word it means just what I choose it to mean—neither more nor less." Recently the Council of the American Chemical Society, also operating in a wonderland, redefined petrochemical to apply only to chemicals from rocks. The editors of *Industrial and Engineering Chemistry* are more liberal and accept the word for what it is, not for what it may have been. However, they rather plaintively hope for a more careful delineation of its scope.

Our language is dynamic, a fitting complement to the dynamic petrochemical industry, an industry which will not be disturbed by the rocks in petrochemical. Long after the Council, the editors, and just plain petrochemists have gone, there will be compounds and elements derived from petroleum and natural gas and intended for chemical markets. These compounds will be called petrochemicals. Words and their meanings come by evolution—not resolution.



Above, test car with minimum instrumentation needed for fuel rating.

How Ethyl Research equips a car for accurate fuel ratings

Ethyl Research has for years been active in developing more accurate and economical ways of obtaining fuel ratings on the road—offering refiners convenient methods for evaluating their gasoline stocks.

At Ethyl Laboratories, we have found that the various road rating procedures can be adequately handled by a grouping of just five instruments, some of which can be seen in the picture above. But we have discovered that the addition of other key equipment (see right-hand page) can facilitate your road testing operations.

Our people have accumulated hundreds of thousands of miles of road testing experience with this equipment. If you would like more

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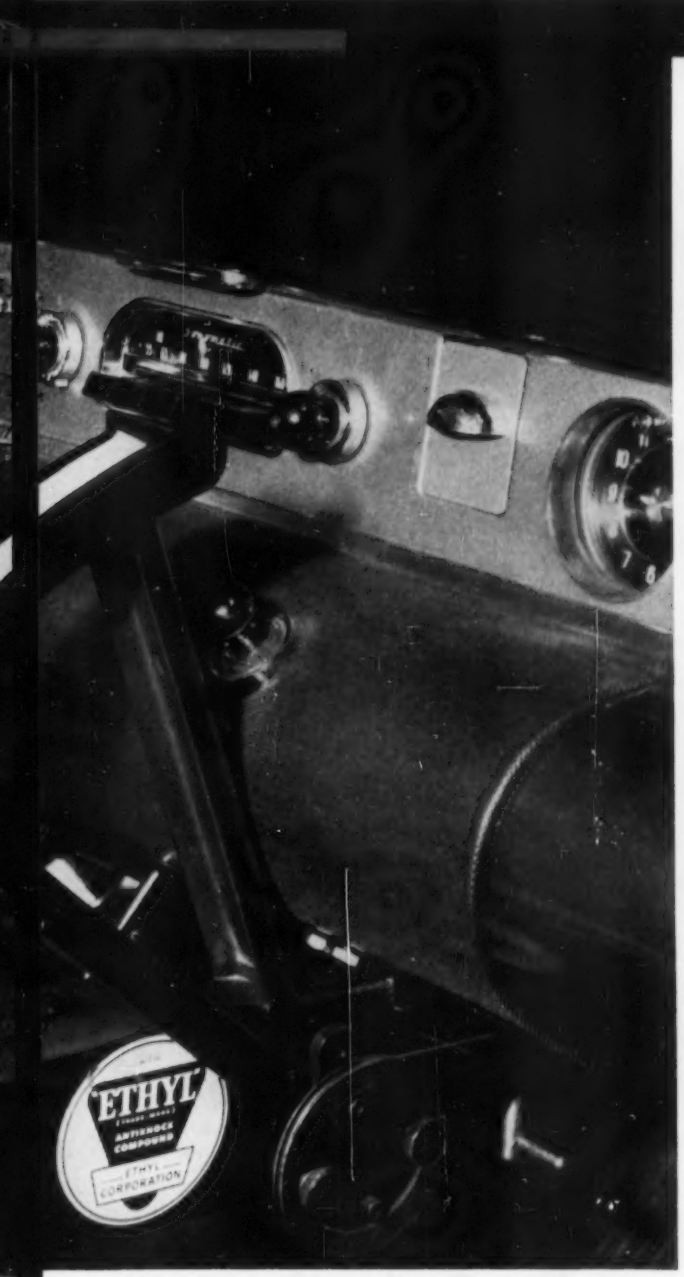

Right, equipment suggested for more complete test-car setup.

information about this subject, please contact your Ethyl technical representative.

INSTRUMENTS SHOWN in this advertisement have proved satisfactory in Ethyl test cars but are not necessarily endorsed by Ethyl Corporation. Although the products of some specific manufacturers are shown, several of the instruments are made by various companies, and we'd be glad to mail you a list of sources. Just send your request to Box 24, Ethyl Corporation, 100 Park Avenue, New York, N.Y.

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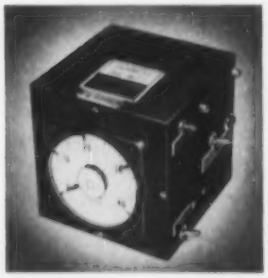
Electronic spark protractor provides an accurate method for continuous indication of spark advance. It gives direct readings at all speeds.

Timing light (above), calibrated flywheel and sight tube are used for obtaining instantaneous spark advance position. Flywheel is marked in crankshaft degrees.

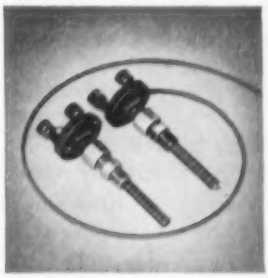
Auxiliary fuel system facilitates testing of several fuels in succession. Simple coupling connects the auxiliary line to the inlet side of the fuel pump.



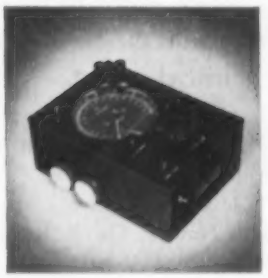
Tachometers are accurate mechanisms for measuring the engine speed. They are adaptable for operation with any six- or twelve-volt system.

Vacuum gauge is required for part-throttle ratings. At any given car speed, the vacuum gauge permits reproducing part-load conditions.

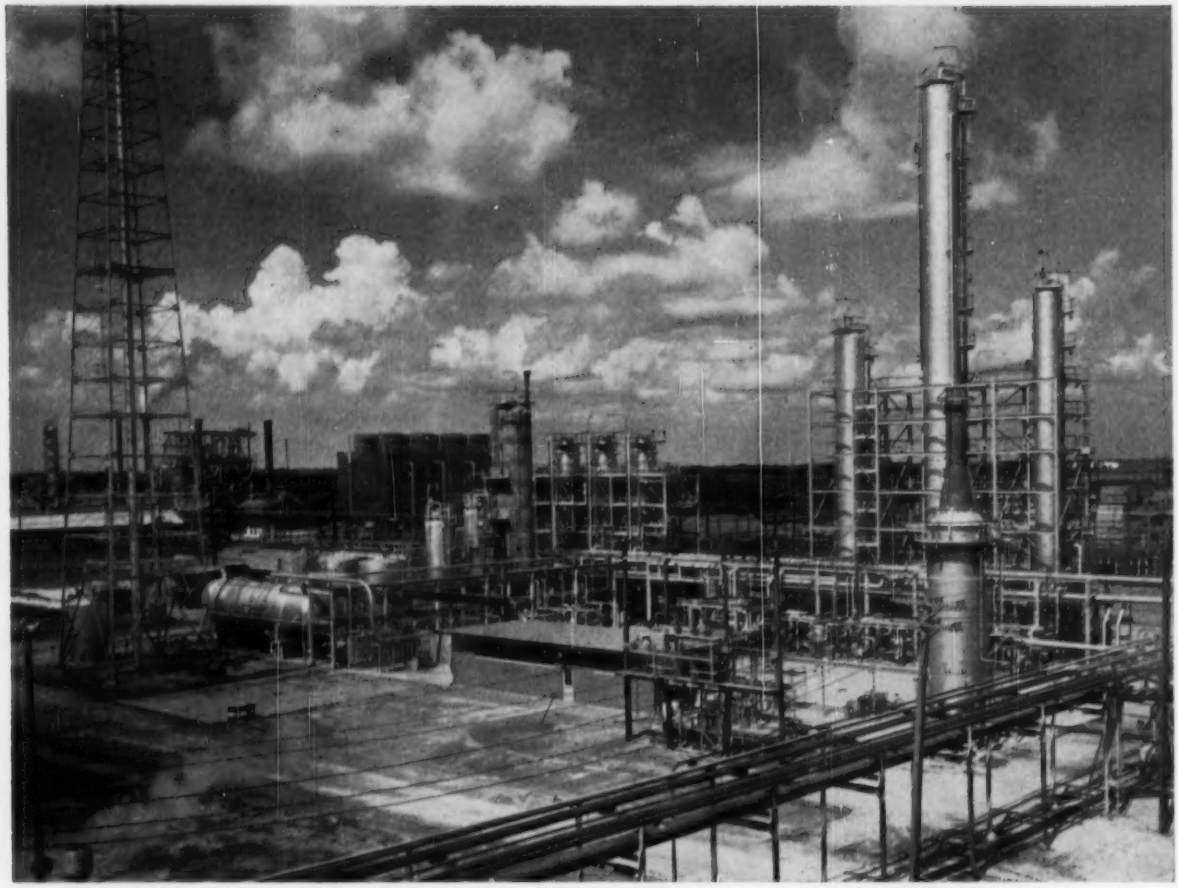
Selector switches for thermocouples and resistance bulb thermometers are needed to permit reading temperatures at various locations.



Thermocouples and resistance bulbs are used to measure the temperatures of the coolant, the lubricating oil, and the air entering the carburetor.



Potentiometer is used to indicate the temperatures measured by the thermocouples. Road ratings require a rugged instrument, insensitive to vibration.



Catalytic-polymerization unit built at Baytown, Texas, in 1954.

In the Postwar Decade . . .

Baytown Refinery Virtually Rebuilt

Ten years of construction, to keep up with the increasing demand for higher octanes, improvements in refining techniques and the discovery of new uses for refinery byproducts, has seen Humble's refinery take on more and more the character of a chemical plant.

YOU NEVER finish building a refinery.

Or at least that has been the case with Humble Oil & Refining Company's 282,000-barrel-a-day (crude capacity) plant at Baytown, Texas.

When World War II ended this refinery was about 25 years old and had a daily capacity of 160,000 barrels. In the decade since, it has been virtually rebuilt.

Changes in the plant—already one of the largest in the U. S.—came with the increasing demand for higher-octane gasoline; improvements in refining techniques, and the discovery of new uses for refinery by-products.

And as new facilities were installed to meet the stiffening competition to turn out higher-quality gasolines, solvents, lube oils, and other petroleum products, the refinery began to take on more of the character of a chemical plant.

Today, the plant produces a wide variety of chemical intermediates form the various refinery streams. This mounting emphasis on petro-

chemicals also has been intensified by Humble's acquisition of Baytown facilities formerly owned by the government for the production of Butyl-rubber, butadiene, toluene, and xylene.

Refining Equipment—Since the war, each of the refinery's two catalytic-cracking units has been expanded to its present fresh-feed capacity of about 55,000 barrels a day. Originally each of these units had a daily capacity of only about 15,000 barrels. Meanwhile, Humble was reducing its thermal-cracking capacity, and today the older thermal units are used only for visbreaking asphalt and cracking catalytic cycle gas oil.

As new units were built and old ones improved, equipment which had become less efficient was dismantled to make way for new construction.

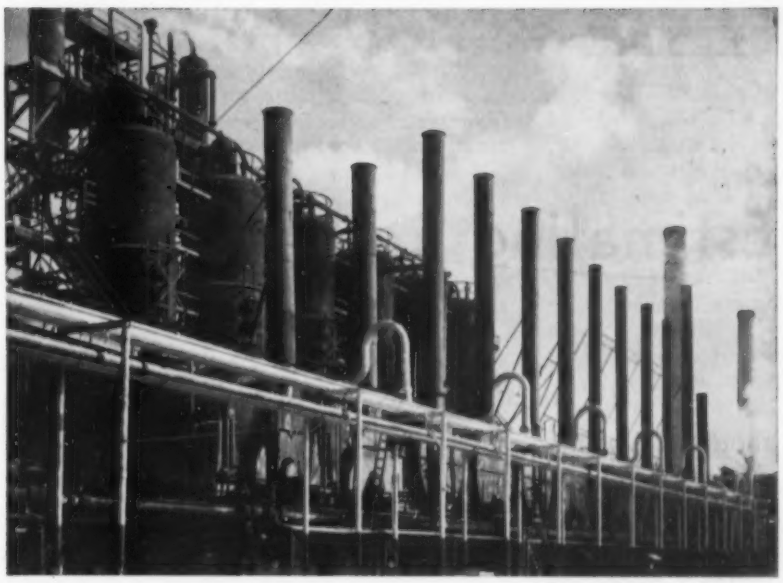
Six batteries of old shell still distillation units were town down. To replace them, Humble has put up three new pipe stills since 1945. These, with the three pipe stills in operation when the war ended, gave the refinery its present crude capacity of 282,000 barrels a day.

Two of the older pipe stills were modified and are now being used for re-run service. The capacities of the pipe stills in crude service range between 50,000 and 85,000 barrels a day each.

Other outmoded facilities which have been scrapped include the old copolymer plant, an old flash-coil unit, a cracking-coil battery and the thermal-polymerization unit.

Other major new equipment added to the refinery includes: A non-lube deasphalting plant, another catalytic light-ends unit, a catalytic-polymerization unit, a MEK dewaxing unit, Hydrofining units, platinum-Hydroforming units, and new treating facilities. Major expansions have been made in processing equipment and in power and steam facilities.

The deasphalting unit, with a daily capacity of some 28,000 barrels, has a deasphalted-oil yield of about 50 percent. This unit recovers more of the virgin fractions from crude bottoms than would be possible with vacuum distillation. Thus it has the effect of increasing catalytic cracking feed stocks and thereby increasing the yield of motor gasoline and other valuable fractions while reducing the yield of fuel oil per barrel of crude distilled.



Before—Shell Still Battery A. Dismantled in 1948.

After—Pipe Stills 5, 4, 3 and 6. Built in 1950, '49, '41 and '54, respectively.

To replace the thermal-polymerization unit and to have the refinery's output of normal butane and LPG products for expanding markets, a catalytic polymerization unit was installed. This new facility produces both high-quality gasoline components and chemical intermediates.

Other refinery construction at Baytown has included expansion and modernization of the alkylation plant and electrical coalescing facilities for treating heating oil and kerosine. In the alkylation plant, Humble has improved both quality and capacity, boosting output from 7,000 barrels a day to about 12,000 barrels. All grades of aviation gasoline are produced.

The quality and yield of motor oil were improved by the new MEK dewaxing plant. A new catalytic light-ends unit—the second at Baytown—was added to permit a greater recovery of catalytic butanes and propanes.

The biggest item on the program for 1955 was the expansion of Hydroforming facilities. One unit was con-

Continued on Page 244

Research Problems

Estimating Research Cost

It's not as hard as you may think. Here's what one research director says about estimating.

Judson S. Swearingen
Southwest Research Institute
San Antonio, Texas

IT IS GENERALLY supposed that the unknown elements in most any research problem preclude the establishment of realistic cost estimates of performing an investigation. However, the cost of the steps in a research program can be estimated with reasonable accuracy; and this makes it possible to appraise programs in advance and to select the most advantageous one. Indeed a program does not deserve to be considered research until it has passed this test.

It is possible to estimate the components of the cost because in almost any research problem where a fairly definite objective has been established, much more information is already available regarding the solution than frequently appears when the problem is first presented. The information thus available, together with known principles and related published technical data, usually permits the selection of a limited number of approaches to a solution of the problem. These approaches usually encompass the area from which the specific solution is expected.

For example, suppose a new type of chemical were to be developed, such as a corrosion inhibitor, an ad-

To develop an additive of moderate value . . .

Steps	Cost
1. Collection of information	$1,000
2. Literature search	1,000-1,500
3. Review and formulation of a program	1,000-1,500
4. Laboratory work	10,000-15,000
5. Planning of production and compounding	3,000-5,000
Total Cost	$16,000-24,000

ditive, or a similar material. Information of the following nature would probably be available:

1. The selling price in terms of effectiveness (based on the price of competitive alternatives and knowledge of the market).

2. Physical characteristics, such as solubility, volatility, etc. (determined by the specific application).

3. Restrictions as to raw materials that may be used.

4. The justifiable expenditure on the investigation (determined by the potential market and the likelihood of success based on previous related research experience).

The intensity and scope of the program to be applied to the problem would depend, of course, upon the expenditure indicated as economically feasible by the market potential and the probability of success. The key to success in research is the selection of the route most likely to produce favorable results in the expenditure range which is justifiable.

Three possible levels of investigation could involve, respectively:

1. For an objective of moderate value such as the compounding of a marketable product, the only route available (if one is justified) is a low-cost program based on the collection of data on inhibitors and a test program to determine the best single material or best combination of materials.

2. For a more valuable objective, the most profitable route may be a moderate-cost program involving a collection of information on inhibitors for careful study, the visualization of one or two likely solutions, and the methodical exploration of one or both of them.

3. For the case of an objective of great value, the most justifiable program would be a high-cost exhaustive study in which many people in many fields would be consulted for ideas, of which a number would be examined for merit and for leads to further ideas.

By considering the importance of the solution and estimates of the chances of success by these various available routes, it is possible to decide the type of program that should be applied to the problem.

Assuming, for example, that level No. 2 would best meet the requirements of this research objective, the program would consist of the following steps, of which the respective cost of each can be estimated:

1. The collection of available information, especially practical information, as to field requirements.

2. A literature and patent study to collect pertinent information on inhibitors (or additives or the like) generally and to look for types or clues as to types which may apply to this particular case.

3. The digestion of this information by professional people specializing in the pertinent fields, such as colloid, organic, or physical chemistry, for the purpose of recognizing and weighing routes of investigation.

4. The execution of the laboratory work, which would involve preparation of test materials, development of a test method, examination of proposed materials, and the like, in a general program for following out leads or trends or other indications pointing to the area in which the answer may lie.

5. Assuming success in Step No. 4, this phase would be concerned with compounding a marketable product to solve the problem of packaging, or solubility, or cost of production, or whatever problem is anticipated in the production and marketing of the product.

Meet the Author

JUDSON S. SWEARINGEN is director of the Petroleum Technology division of Southwest Research Institute. Before joining the institute in 1948, he was prominent in several important industrial developments. These included scientific investigations of synthetic gasoline and tonnage oxygen processes in France, Germany and Czechoslovakia; service as technical advisor on styrene to Mathieson Alkali Works, and as designer of turbines and pumps used in rockets. With nine others, he was cited by National Petroleum News as a key scientist in the Manhattan Engineer Project. From 1939 to 1942, Dr. Swearingen was professor of chemical engineering at the University of Texas. He is author of a number of articles and patents in the chemical field.

The cost of these steps is capable of estimation based on experience. The intensity of each can be varied, dependent upon the care with which it should be carried out, and that in turn would be predetermined by the value of the product and the importance of a successful solution to the problem.

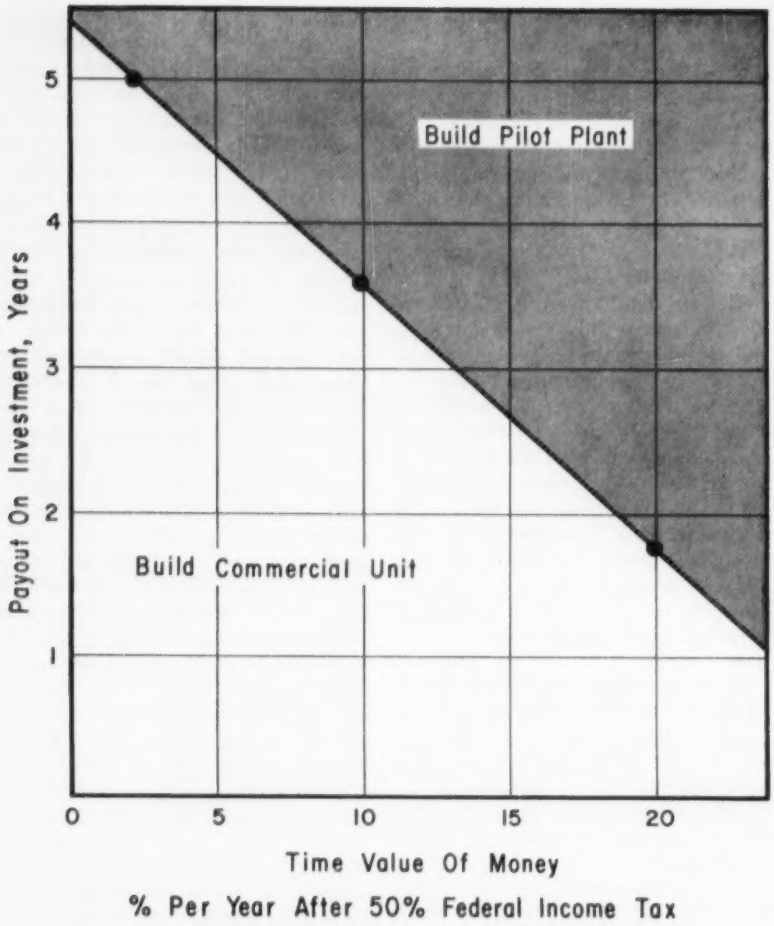
Assume that a program sufficiently comprehensive to cost $20,000-$25,000 is justified. In a balanced program, Step No. 1 (collection of information), would usually cost less than $1000. Step No. 2 (literature search) would depend upon the amount of material to be examined and studied by chemists and would require an expenditure of approximately $1000 to $1500 for a program of this magnitude. Opinions as to the cost of this step are generally available from men familiar with the field. Step No. 3 (review and formulation of a program from these findings by related specialists) can usually be accomplished for $1000-$1500. The cost of Step No. 4 (the laboratory phase of the problem) is a little like the number of questions in the game of Twenty Questions, in which, if judiciously planned, twenty questions are usually enough to get an answer. Similarly, the courses offering best chances of success can usually be explored for $10,000 to $15,000.

In this phase, the most expensive of the program, reappraisal of the chances of success can be performed at regular intervals as a guide to shortening or expanding the program. This is very important. It is here where substantial savings can be made—altering the course of work, if necessary, or even terminating the work if results are insufficiently encouraging, thereby saving a substantial portion of the appropriation. Finally, the planning of production methods, the compounding of the material, and similar operations (excluding any broad test program for marketing purposes) usually require an expenditure of $3000 or $5000. This is a total of $16,000 to $24,000.

With research costs as definite as this, it is understandable that research expenditures (excluding government) in the U. S. are so rapidly increasing—40 percent increase from 1949 to 1952.[1]

LITERATURE CITED

[1] A. H. Rubinstein: Coordination, Control and Financing of Industrial Research, King's Crown Press (1955).



If the payout of the commercial plant is greater than 5.4 years, a pilot plant should be built even if there is no return on the interim use of the money in this analysis.

Research Problems

When to Use a Pilot Plant

Applied to new processes, the pilot plant can be a big money saver; but first these questions must be answered.

John W. Payne
Socony Mobil Oil Company, Inc.
Paulsboro, New Jersey

PILOT PLANTS find their widest use in developing new processes. To decide when to use a pilot plant for this development, these questions must be answered first:

- Extent of application of the process?
- How soon is the process needed?
- How much is unknown?

During each development, the question of whether to build a pilot plant has arisen. To answer this question many things should be considered:

1. Extent of Application—Generally if the process is going to be used in only one or two commercial installations that are not too expensive, then only a limited pilot plant program is justified. On the other hand, if many installations are contemplated, a very elaborate pilot plant program may be indicated. Each case must be considered on its own merits.

In most instances in the petroleum industry a process is applicable in many refineries. If the process could be put in one refinery and thoroughly tested before finalizing the design for the other refineries, this would permit mistakes to be corrected without too much cost. Often this is not the case. A large number of units will be designed and partially built before the first one goes on stream. In this case, the cost of mistakes is multiplied by the number of units under construction.

2. How Soon Is Process Needed?—Usually, new processes are needed right away. After a process has been conceived and developed in bench-scale equipment to the point where the economics look attractive for commercialization, the company is losing money every day that it has to wait for the process to be put into operation. As an example let us assume that a commercial unit will cost $5 million and will have a payout of four years after 50 percent federal income tax. We may suppose that to develop a sound commercial design, a two-year pilot plant program will be required and will cost $500,000. At the end of the two-year pilot plant program the commercial unit is designed and built during the next two years and then operates as per design. Thus at the end of four years we have an operating plant at a capital cost of $5 million and a development expense of $500,000.

As an alternate, suppose we don't pilot plant this process. We take the bench-scale data and immediately design and construct a commercial plant. In this case we overdesign to be on the safe side. It takes us 2.5 years to design and build this unit (in the previous unit some design work was going forward during the pilot plant

operation) and the cost is $6 million. When the commercial plant is built it doesn't operate right, and has to be shut down and parts of the plant rebuilt. This is done in a total time of six months and at a cost of $1 million. Thus after three years we have a plant with a capital cost of $6 million, and modification expense of $1 million; whereas before, after four years, we had a plant cost of $5 million and a development expense of $500,000.

Thus by skipping the pilot plant we have increased our capital cost by $1 million and our expense by $500,000. For this extra money we have been able to get our commercial unit into operation one year earlier.

In the example, the decision to build or not to build the pilot plant depends on the rate of return on the interim use of the money which will be used to build the commercial plant. An economic analysis shows that if the rate of return on the interim use of the money is more than 7 percent (after tax) we should build the pilot plant; but should skip the pilot plant if the rate of return is less than 7 percent. Similarly, if the payout of the commercial plant is greater than 5.4 years, we should build the pilot plant even if there were no return on the interim use of the money.

Of course none of the actual cases are as simple as the example above, but it does illustrate the type of pencil work that should be done in deciding whether to build a pilot plant.

3. How Much Is Unknown?—A careful analysis of what is unknown about a new process will dictate the type and size of a pilot plant to be built.

There are three categories of unknowns encountered in developing a process. One category is the kind that can be indicated in bench-scale equipment and calculated with a fair degree of accuracy. This category includes such things as reaction rate, heat of reaction, pressure drop, desired space rate, and other processing conditions; and (where catalysts are used) catalyst aging rate, and catalyst life. With the above factors determined or calculated, it is possible to design these factors into a commercial unit with a fair likelihood of successful operation.

The second category of unknown is that associated with flow of gases, liquids and solids (granular or powder) and their interactions in large units. Some of these unknowns can be calculated rather than determined by step-wise pilot plant development.

The ones that can be accurately calculated are those in which any nonuniformity of flow is self-correcting. Examples of this type of process are:

(a) Countercurrent heating of a flowing bed of solid particles by means of a hot gas. In this instance if the gas should tend to flow faster through one side of the bed than the other the fast flowing gas will not be cooled as quickly by the solids, will have a higher viscosity and a greater resistance to flow, and will be self-correcting to uniform flow.

(b) Contact of a gas or vapor with a fixed bed of granular solids in which there is an endothermic heat of reaction such as obtained in fixed-bed catalytic reformers. Here the inlet vapor is at a higher temperature than the catalyst and cools while

Which route to a commercial unit?

Using a Pilot Plant

	After	Cost
Pilot plant program	2 years	$ 500,000
Commercial unit	4	5,000,000
Total Cost	4 years	$5,500,000

Advantage: **Cost cut $1,500,000 plus delayed investment.**

Without a Pilot Plant

Commercial unit	2½ years	$6,000,000
Modifications necessary	3	1,000,000
Total Cost	3 years	$7,000,000

Advantage: **On-stream 1 year earlier.**

passing through the reactor. If the vapor should tend to flow faster through one section of the bed it would be cooled less by endothermic heat, would have a higher viscosity and greater resistance to flow, and would be self-correcting to uniform flow.

Processes of the above type can be calculated from bench-scale results without benefit of pilot plant experimentation.

The type of flow that causes so much trouble is the unstable type, in which non-uniformity is self-aggravating rather than self-correcting. Examples of this type of process are:

(a) Counter-current cooling of a flowing bed of granular solids by means of a cool gas. In this instance any non-uniformity of gas flow will aggrevate itself because the more rapid flow of gas through one section will develop a cool path through which abnormally large volumes of gas will flow.

(b) Liquid-granular solvent extraction in which the solvent becomes more viscous as it flows down through the bed of solids. In this instance any non-uniformity of flow aggravates itself; the slow-moving zone becomes increasingly more viscous and moves slower still.

(c) A down flow liquid-granular solid extraction process in which the solvent becomes less dense as it flows down through the bed. In this example the denser solvent at the top level in the extractor attempts to rush to the bottom of the vessel and displace the rich solvent upward in the vessel, thus setting up internal recycling.

Many of these unstable flow systems can be changed to a stable system by reversing the direction of flow or by a temperature adjustment. If such a dodge is not feasible, then put in positive control devices, because such non-uniformity gets worse as the diameter of the vessel gets larger. It is cheaper to analyze the flow problems and provide for the solution in the design or pilot plant stage than suffer with them in a completed commercial unit.

The third category of unknowns is that in which one moving phase adversely influences the movement of a second phase involved in the process. This includes such processes as counter-current contact of liquid with liquid in solvent extraction, gas with liquid in fractional distillation or gas absorption, and contact of gas with solids in fluidized solids.

In such processes stable uniform counter-current operation cannot be obtained, so we must either be content with one contact and low effectiveness, or resort to stage operation. Thus the phases can be contacted, separated, redistributed and recontacted in a counter-current sequence, as in a bubble tray fractionation tower or in any of the well-known liquid-liquid solvent extraction processes.

Most of these unstable flow processes give nice counter-current operation in a small diameter vessel (up to a few inches) but as the vessel diameter gets larger, the results get poorer. Materials flowing through a vessel like to follow the easiest path, and two phases never flow in a truly counter-current manner if both have freedom of movement; they start internal cycling or bypassing.

If it is decided that stage contacting, separation and recontact will be practiced commercially, then a small pilot plant is ample. But if for economic reasons it is desirable to build a commercail unit in which non-uniform flow will take place, then the bigger the pilot plant the better, because large-scale performance cannot be calculated and only a full commercial size will give the final answer.

What Kind of a Pilot Plant?—A careful analysis of the unknowns will indicate whether pilot plant work should be done. Seldom is it necessary to build a full-fledged pilot plant. The better approach is to establish what part or parts of the process cannot be calculated, and investigate these separately in mock-up models. In developing the TCC process we studied the flow problems in wooden and glass models at room temperature, and we used okra seed instead of bead catalyst before the bead plant got into production.

Things Not to Do—1. Don't clutter up the pilot plant and becloud the main item of investigation with a lot of auxiliary equipment just to duplicate full-fledged commercial operation. It slows down the results and generally contributes nothing.

2. Don't build a pilot plant of the same geometry as the proposed commercial unit and expect the results to extrapolate to commercial performance. Too many critical things such as linear velocity and heat transfer rate change with increase in size.

3. Don't build a pilot plant to demonstrate an uneconomical process in the hope that the pilot plant will make the process look better. Usually unexpected things show up in the pilot plant that require a more complicated and expensive design. However, a pilot plant is a great boon to a promoter. He can point to the pilot plant as a demonstration that his scheme is operable.

4. Don't try to build a pilot plant out of the materials of construction of the contemplated commercial unit in order to evaluate corrosion. This results in a waste of on-stream time. Study corrosion in separate equipment and put test specimens in the pilot plant.

5. Don't build a pilot plant to determine things that can be found out in bench-scale equipment. Data come faster and cheaper from bench-scale units.

6. Don't build a pilot plant because you are too lazy to *calculate* the commercial design. ##

Meet the Author

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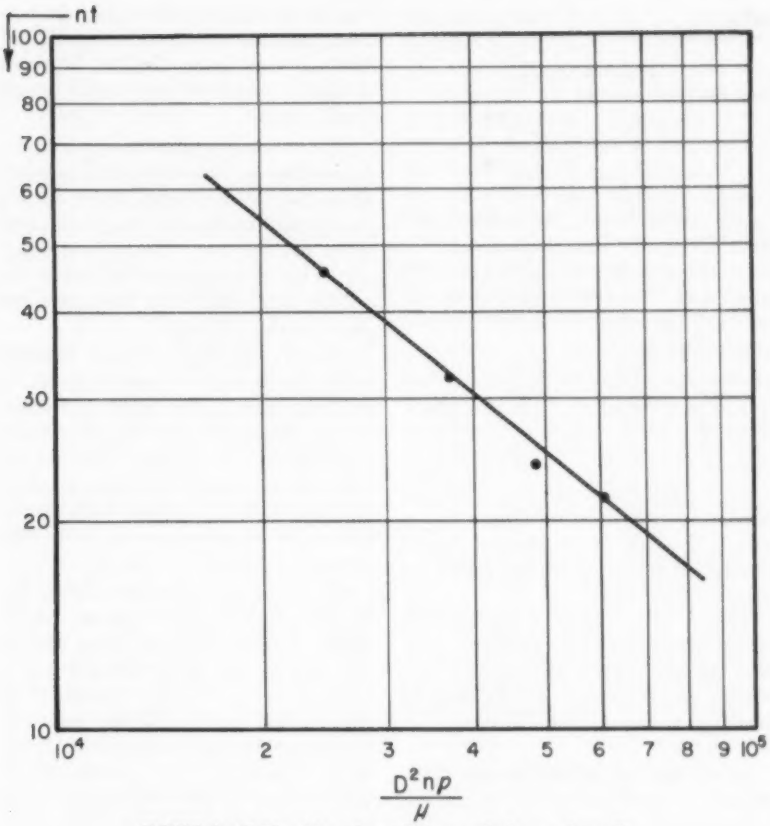

FIGURE 1—Fluid mixing data: This correlation works well.

Research Problems

How to Scale Up Pilot Plant Data

It's a tricky business. Examples here on mixing, distillation, and reaction rates show varied techniques.

D. G. Jordan
American Cyanamid Company
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THERE IS no magical procedure for scale up. There are as many different scale-up methods as there are methods for uncovering the relationships between physical phenomena. If scale-up methods can be said to have a common methodology, it is this:

1. Something is measured on a small scale, usually but not always on a scale model of the proposed plant apparatus.

2. The measurement is correlated with the controlling variables.

3. The resulting correlation, which is now a design equation, is used to design the large apparatus.

Experimental data may be used for design purposes (scale-up) in several ways:

1. The situation may be new, but the experimental data fit a well-known design equation quite well so that all the experimenter does is to evaluate constants for insertion into the equation or prove the applicability of the equation to the new situation. Pressure drop through a bed of packed solids is quite often like this.

2. The experimental results are correlated by the techniques of dimensional analysis, and the resulting system of dimensionless groups form a design equation. Scale-up is done, not on a basis of strict dynamic similitude, but within the framework of the dimensionless group equation which describes the physical phenomenon. Most of our heat transfer equations are of this type.

3. There may be no equation at all. In this case strict adherence to dynamic similitude is required. This means that the dimensionless groups must have the same numerical value. Mixing experiments are sometimes scaled up in this manner.

There are many treatises on similitude. The reader is referred to the papers of Rushton,[10,11,12] Green,[4] Klinkenberg and Mooy,[7] and the writer's recently published book, "Chemical Pilot Plant Practice."[6]

Scale-Up of Fluid Mixing Data—As an illustration of the use of a dimensionless group expression, let us consider a problem in fluid mixing scale-up. We shall assume a fully baffled cylindrical tank equipped with a turbine-type agitator. We shall also assume that the pilot plant mixer is designed so that it is a scale model of the proposed large (plant) mixer. Using a scale model is the act of preserving geometric similitude. As we shall see, this is important.

Fluid mixing scale-up is hampered by the lack of a measure of the "goodness" of mixing. However, it appears that one method for doing this is to measure some property of the mixed mass during mixing, say electrical conductivity or refractive index, and measure the time required for this property to become uniform. It should then be possible to plot log nt against log $\frac{D^2 n \rho}{\mu}$ (Reynold's number) and obtain a correlation. Since n is revolutions per unit time, the product nt is a dimensionless group. The use of this kind of correlation

was first proposed by Danckwerts[2] and exploited by Jordan[6] in his book on pilot plants. Figure 1 shows that it works quite well. The data are those of Wood, Whittemore, and Badger.[14]

Having made the measurements on the model and obtained the correlation, an expression may be written:

$$nt = C\left(\frac{D^2 n\rho}{\mu}\right)^x$$

x is easily obtained as the slope line of Figure 1. It is approximately —0.8. This exponent is a function of the system geometry and is partially under the experimenter's control. Therefore,

$$nt = C\left(\frac{D^2 n\rho}{\mu}\right)^{-0.8}$$

Now there comes the heart of the scale-up procedure. We say that, since we shall preserve geometric similitude and since we have experimented on the same fluids as will be used on the large scale, the expression applies to both scales. That is, we have discovered a relationship which is independent of the size of the apparatus. Designating the small (experimental) scale by small letters and the large (plant) scale by capital letters, two expressions may be written:

$$Nt = C'(D^2N)^{-0.8}$$
$$nt = C'(d^2n)^{-0.8}$$

These may be solved for t:

$$t = C' D^{-1.6} N^{-1.6}$$
$$t = C' d^{-1.6} n^{-1.6}$$

Usually we wish the times for mixing to be equal, but all we need is a relation between the two times and this may have any value. For simplicity, we shall assume equality, then:

$$D^{-1.6} N^{-1.6} = d^{-1.6} n^{-1.6}$$

or

$$\frac{N}{n} = \left(\frac{d}{D}\right)^{0.80}$$

The ratio d/D is the scale-up ratio, and it is related to the desired volume change by the cube root. If V = 1000v, then D = 10d. Substituting this in the above equation, we have:

$$\frac{N}{n} = (0.10)^{0.80} = 0.13$$

or the agitator speed required for the large mixer is 13% of the model agitator speed. Usually in experiments of this type the agitator speed is the only variable under the experimenter's control.

The power consumption may also be scaled up by use of a relation due to Rushton.[12]

$$P/p = N^3D^5/n^3d^5$$

but since

$$\frac{N}{n} = \left(\frac{d}{D}\right)^{0.80}$$
$$\frac{P}{p} = \left(\frac{D}{d}\right)^{2.60}$$

The table below, taken from Jordan,[6] shows the N/n, P/p, and power per unit volume ratio for a volume change of 1000 (scale-up ratio of 10) as functions of x (the slope of the correlating line).

x	N/n	P/p	P/V
—0.5	0.22	1000	1
—0.7	0.15	340	0.34
—0.8	0.13	214	0.21
—0.9	0.11	141	0.14
—1.0	0.10	100	0.10

Note how important it is that the absolute value of x be large. If x is small (—0.5) it might be that a change of mixer geometry would increase it.

Other illustrations are possible using heat transfer or pressure drop, but the method is the same. The reader is referred to the writings of Rushton,[10] Green,[4] and Jordan.[6]

Scale-Up of Distillation Columns—A problem of much interest to chemical engineers is the prediction or scale-up of distillation column efficiency. The methods available for the calculation of the theoretical height of a column are well known and satisfactory enough. However, the efficiency of the individual trays is a function of the tray geometry, the vapor and liquid rates in the column, and the physical properties of the materials being distilled. It is not a simple problem but one of much importance.

There is much present-day interest in distillation contacting devices other than bubble-cap trays. Sieve plates, turbo-grid trays, cascade trays, and what not are now coming into wider use. The method described below for scaling up bubble-cap trays also applies to the others.

Nearly all engineers are familiar with the fact that mass transfer is fundamental to the unit operations of gas absorption and solvent extraction. Distillation is also a duffusional unit operation, and it is to mass transfer theory that we must turn to explain the phenomenon of tray efficiency.

In order for a molecule in the liquid phase to get into the vapor phase, it must pass the phase boundary and so also must a vapor molecule to get into the liquid. The present-day picture of the gas and the liquid film resistances in series has been examined rather closely by many workers and a procedure developed for evaluating both independently of the other and then combining them so as to get a good picture of the transfer mechanism. The technique which has been adopted combines both mass transfer theory and dynamic similitude.

First a scale model of the desired tray is built, and then the individual film resistances are measured. The gas film resistance can be evaluated by blowing air through water on the tray and measuring the moisture pickup. With this system there is no liquid film resistance, and the whole resistance to transfer of the water into the air is in the gas film. The effect of gas rate, liquid rate, and tray geometry may be studied. The results may be reported in a variety of ways such as a mass transfer coefficient, the number of transfer units, or a tray efficiency. In order to measure the liquid film efficiency, dissolved oxygen may be stripped from water by air blowing through the plate. In this system essentially all the transfer resistance is in the liquid film. Here, too, the effect of gas and liquid rates and tray geometry may be measured. The two resistances may be combined and a good picture obtained of the efficiency of the tray

Meet the Author

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and the effect of various tray geometries and fluid rates on that efficiency.

$$\frac{1}{-2.3 \log (1 - \eta_{OG})} = \frac{1}{N_G} + \frac{mG/L}{N_L}$$

In order to transform the system from air-water to the one of interest, the use of a ratio of dimensionless groups (the Schmidt number) is employed.

$$N_{LP} = N_{LB}\left[\frac{\left(\frac{\mu}{\rho D_r}\right)_B}{\left(\frac{\mu}{\rho D_r}\right)_P}\right]^{1/2}$$

$$\text{also, } N_{GP} = N_{GB}\left[\frac{\left(\frac{\mu}{\rho D_r}\right)_B}{\left(\frac{\mu}{\rho D_r}\right)_P}\right]^{1/2}$$

In a series of papers the workers at the University of Delaware have described their progress with this method. To anyone interested in tray efficiency prediction or scale-up, these papers make fascinating reading. A recent paper[3] from this group shows just how successful the method has been. In collaboration with workers at the Neches Butane Products Company, a detailed description is given of the application of the results of the air-water-oxygen work at Delaware on a model of the proposed tray. In addition, a comparison of experimental and plant results is given.

At Delaware a model of the tray was built and its efficiency measured by humidifying air and stripping oxygen. Its tray geometry was varied so as to measure the effect of various cap designs on hydraulic gradient and contacting efficiency. The results were transformed from the air-water system to the furfural-hydrocarbon system by application of the ratio of the Schmidt numbers, and the effect of vapor and liquid rates was accounted for by using the same rates as the proposed plant, thus preserving geometric and kinematic similitude. The final result was almost complete agreement between the efficiencies predicted from the model work at Delaware and the actual efficiencies calculated from test work on the column at Port Neches.

The success of this method is really striking when it is considered that the model work was done on an air-water system and the plant work on the extractive distillation of a furfural-hydrocarbon system. Two more unlike systems could hardly be imagined, and the success of the proceduces indicates that this is a powerful method indeed.

Scale-up of Laboratory Reaction Rate Data—The design of the chemical reactor system is probably the most difficult and the most important task of the chemical engineer. The science of applied reaction kinetics can hardly be said to have reached the same stage of utility to the average practitioner as have heat transfer and distillation. Writers in this field recognize this fact, and the recent literature contains many valiant attempts to solve specialized problems in reactor design. Most of these papers start from an assumption that basic data are available and that certain formal reaction schemes are followed.

Many of these formal schemes have been solved by application of considerable mathematics, and the results are doubtless useful if it is known in advance that the system under investigation follows the reaction scheme treated by the authors.

Several writers have recognized the need for a formal design procedure which is valid even though the reaction scheme is not known or if it is hopelessly complicated from the computational aspect. To a point, these writers have succeeded. However, most of these papers consider that a rational design can be achieved by consideration of only one of the components of the reaction, or of three at the most.

Engineers concerned with process development know only too well that the situation is quite complex and that most of the proposed schemes are oversimplified. An industrial reaction will likely have four, or six, or more components of interest and almost any kind of a chemical reaction may be proceeding. For any new reaction, or reaction involving new intermediates, an attempt at rational analytical treatment seems hopelessly complex and time consuming. However, some sort of a design must be made, and any and all methods will be tried. In the material below, the author will present a new method which is applicable to relatively slow reactions which are conducted primarily in the liquid phase and are suited for a continuous-stirred tank reactor system where there is perfect mixing. It is also applicable to reactions in which one or more of the reactants is a gas or a solid. Basically, it is similar to the methods of Weber,[12] Jones,[5] and the newer and better treatment of Bilous and Piret[1] in that it is not necessary to know the order of the reactions nor the type (consecutive, parallel, or what not) but differs from their methods in that any number of components may be treated.

At the outset it is assumed that data are available from the laboratory in the form of a plot of concentration of all the reactants and products against time for a batch reactor. Since the engineer is interested in designing a continuous reactor, and he is well aware of the distribution of residence times in continuous reactors, he will be interested not only in the time history of the reactants and the desired products but also of the by-products. He knows that any prediction of the distribution of products (and unreacted feed) in the exit stream must contain an estimate of the over-reacted (or otherwise undesirable) material. In addition to this, he would like to know just how large to make his reactor(s) and what effect this change in reactor volume will have on the product distriubtion. The proposed method will do all this.

The first step is to plot the concentrations of all the reactants and the products as a function as time. Such a plot is shown in Figure 2. It shows four compounds: one reactant and three products which could result from a reaction scheme of the type A→B→C→D. However, these curves may take any shape at all, and there may be more or fewer compounds. It is only necessary that the laboratory do the work accurately. Such a set of curves could result from work done in a batch reactor from which samples are withdrawn regularly and all compounds present determined quantitatively, or it might result from reactions done in ampoules which are withdrawn from a constant temperature bath at regular intervals. However it is done, the plot shows the time history of the reactants and products. If the ratio of reactants (there can be as many reactants as we please) is to be varied, then there must be a separate set of curves for each ratio.

Now it is desired to translate this batch reaction to a continuous system. Furthermore, it is desired to carry out the reaction in a stirred

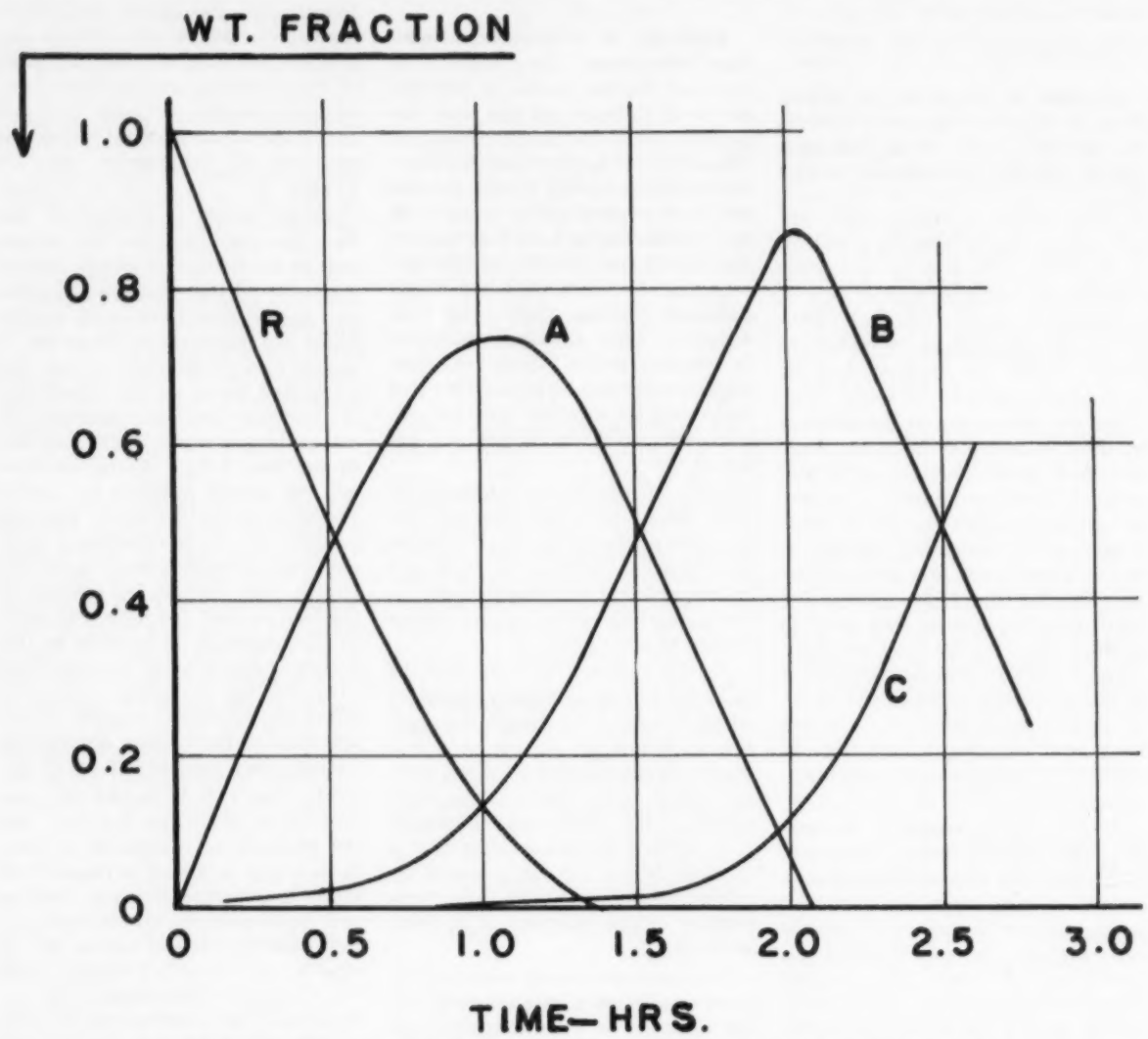

FIGURE 2—First step in scaling-up reaction rate data: Plot all reactants and products as functions of time.

tank or a series of such stirred tanks. This translation is a scale-up problem which involves the effect of reactor size and number on the distribution of residence times and the effect of this residence time distribution on the chemical reaction. The problem of distribution of residence times in a series of stirred tanks has been attacked by many writers and in particular by MacMullin and Weber,[8] who present a series of curves showing the distribution of residence times. This curve is reproduced in Figure 3; Figure 4 extends the first plot to longer times.

So much has been written about distribution of residence times in a series of stirred tanks that there is no point in a detailed discussion here. We shall only say that it is a matter of prime importance, since in a continuous system some of the flowing material will stay in the reactor only a very short time and so be under-reacted and some will stay a very long time and so be over-reacted. The whole spectrum of possible combinations of reactants and products will be made, and the exit stream will have some sort of average composition. This composition may differ appreciably from that of the batch reactor at similar holding times. The more tanks used in series, the smaller each one gets and the closer the product composition will come to that of the batch reactor. In these days of high throughput and high yield, it is important to remember that any practical continuous system will produce more unreacted material and more by-products than a batch system. It is vitally necessary that any design scheme be able to predict the product composition from a continuous system well enough so that a clear idea of both unreacted feed and over-reacted by-products may be obtained.

It is not an easy matter to decide

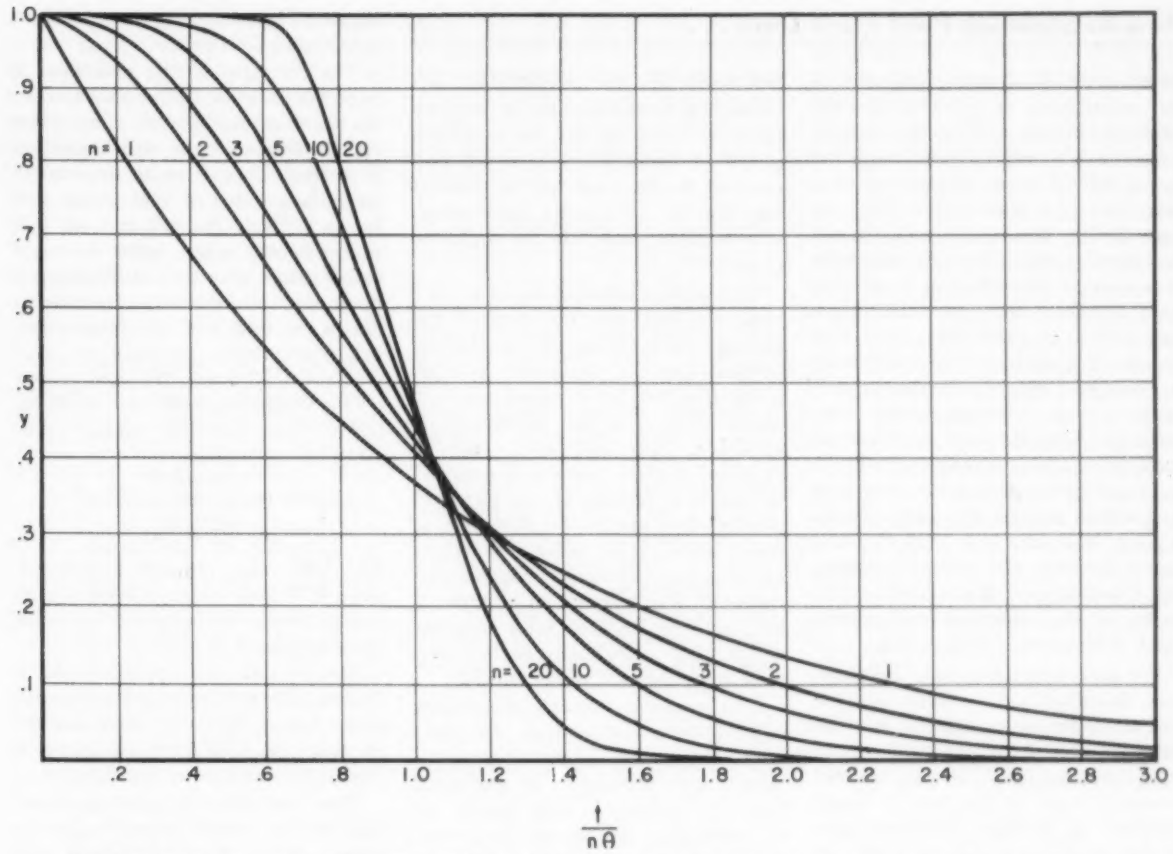

FIGURE 3—Holding times in continuous-flow mixing tanks in series: A way to translate the batch reaction to a continuous system.

first off just how large to make the tanks nor just how many of them to use in series, but a fairly good approximation can be obtained by observing the concentration-time curve and by knowing the kind of product we wish to make. Usually the object is to maximize the yield of one of the products, and a glance at the time-concentration curve will show that this can be accomplished by concentrating the residence times in a region where there is a fair percentage of the desired product, a good deal of unreacted feed, and only a small amount of by-product. Usually high yields can be obtained economically if the conversion is held down, and feed can be easily and cheaply separated. However, a good place to start the calculation is to asume that V/q shall be ¾ of the desired reaction time.

Since q is known from the design production rate, then V can be com-

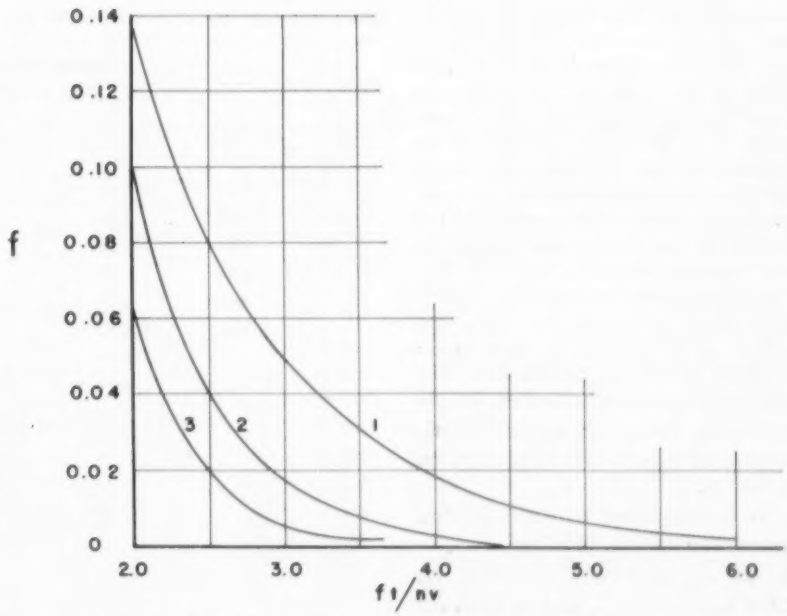

FIGURE 4—Holding itme curve: An extension to the plot in Figure 3.

puted easily. One of the purposes of the calculation is to evaluate the effect of changes in V so that several different V's will be used, and the above rule is about as good as any. Since we now know V and q, we must decide how many tanks to use in series. Again, since our endeavor is to evaluate the effect of n, we may start anywhere since we shall calculate several n's. However, as is well known, it is desirable to concentrate the residence times in a rather narrow range so that it is wise to use many tanks in series. However, if many are used, the capital investment will be high and operational difficulties may be great so that for all practical purposes n is usually 3, 4, or 5. An economic balance will give the answer, but this balance will contain a calculation of the effect on the process yield of changes in V and in n.

We now prepare a table. The column headings are t (time), c_A (the concentration of the feed), c_B (the concentration of the first product), c_C (the concentration of the second product), and so on for as many products as we have. Between each of the columns for concentration, we put a column for $\bar{c}_A$, $\bar{c}_B$, $\bar{c}_C$, and so forth. These are the arithmetic means of the concentrations at any two successive times. We also have a column for f, the fraction of the incoming flow held longer than a time t. This value is read from Figure 3 or 4 at the appropriate value of qt/nV and n. The next column is titled Δf, and this is the difference between the fractions held longer than time t and time t + Δt. Obviously this is the amount of the incoming flow which left the reactor between the two times and was therefore the amount of the incoming flow which was exposed to the reaction condition for that time Δt. That amount of material may be considered as a small batch reaction which, by virtue of its exposure to the reaction conditions for that time, had an average concentration of all the materials given by the arithmetic average of the concentrations between t_1 and t_2.

It is convenient to make another table. The column headings are $t_2 - t_1$, Δf, $\bar{c}_R$, Δf x $\bar{c}_R$, $\bar{c}_A$, Δf x $\bar{c}_A$, $\bar{c}_B$, Δf x $\bar{c}_B$, $\bar{c}_C$, Δf x $\bar{c}_C$, and so forth for as many compounds as we had in the first table. We now multiply the Δf's by each of the $\bar{c}$'s in turn for as many times as we wish. As we approach qt/nV of about 2.5, it is noted that most of the flow has left the reactor and that Δf is becoming quite small. This is particularly true for n greater than 4.

The various columns of Δf x $\bar{c}$ are then summed, and the result is the average composition of the issuing stream from the continuous reactor. Since the sum must equal unity, a quick check on the arithmetic is available. This calculation may be repeated as many times as is required to obtain a picture of the effect of changes in n and V. Furthermore, as stated before, if the ratios of reactants are changed, the whole thing must be repeated. This appears to be tedious, but no more so than many another engineering calculation with which most engineers are quite familiar.

The example worked out below will illustrate the method. The data from the batch laboratory experiments are presented in graphical form in Figure 2. These curves are representative of consecutive reactions, but it is understood that the reactions may be of any type and the curves take any shape. The data shown are products of the author's imagination. They represent the time history of one reactant (R) and three products, A, B, and C. The curves end as shown, but it is reasonable to suppose that as time goes on, B goes to zero and C to unity.

The first step in the procedure is to pick a value of V, the total volume of the reacting system. The value picked depends upon which product is desired. If A is to be maximized, we pick a value of t of about 0.75 hours. If B is desired, a t of 1.75 would appear about right. As stated before, the value of t used depends upon the relative cost of recovering unreacted feed and purifying product. For present purposes we shall pick t = 0.75 hours. We shall assume q (the volumetric feed rate) as 50 cu. ft./hr. Our nominal contact time (0.75 hours) is now

$$V/q = 0.75$$
$$V = (0.75)\ (50) = 37.5 \text{ ft.}^3$$
$$\text{also } \frac{qt}{V} = 1.33\ t$$

The last value remains unchanged, since V is kept constant even though n is changed. All reactors have the same volume.

Now a time unit of 0.2 hours is chosen. The unit used is purely arbitrary, but it should be small enough so that the concentration curve is essentially straight in the interval.

The first table is now prepared. This is for three stirred tanks in series. nV = 37.5 ft.,^{3} but n may have any value from 1 to ∞.

There are several things worth noting about this table. (1) All the Δf's add to 0.9992 which is quite good, since they should add to 1.000. However, the last values are uncertain since they were read from a

TABLE 1—Calculating Δf

t	c_R	$\bar{c}_R$	$\bar{c}_A$	$\bar{c}_A$	c_B	$\bar{c}_B$	c_C	$\bar{c}_C$	1.33t	f	Δf
0	1.00		0		0		0		0	1.00	
		0.90		0.10		0		0			0.05
0.2	0.8		0.2		0		0		0.266	0.95	
		0.70		0.290		0.01		0			0.17
0.4	0.6		0.380		0.02		0		0.532	0.78	
		0.508		0.450		0.028		0			0.21
0.6	0.415		0.528		0.035		0		0.798	0.57	
		0.337		0.598		0.049		0			0.19
0.8	0.26		0.668		0.062		0		1.06	0.38	
		0.196		0.703		0.106		0.001			0.14
1.0	0.132		0.739		0.150		0.002		1.330	0.24	
		0.086		0.729		0.194		0.005			0.10
1.2	0.04		0.72		0.238		0.008		1.60	0.14	
		0.02		0.655		0.312		0.009			0.06
1.4	0		0.590		0.385		0.010		1.86	0.08	
				0.498		0.473		0.015			0.03
1.6			0.406		0.560		0.020		2.13	0.05	
				0.322		0.640		0.036			0.02
1.8			0.238		0.72		0.053		2.40	0.03	
				0.149		0.80		0.083			0.015
2.0			0.060		0.88		0.112		2.66	0.015	
				0.03		0.82		0.169			0.009
2.2			0		0.76		0.226		2.92	0.006	
						0.67		0.316			0.003
2.4					0.58		0.405		3.19	0.003	
						0.49		0.502			0.001
2.6					0.40		0.600		3.46	0.002	
						0.30		0.700			0.001
2.8					0.20		0.800		3.72	0.001	
						0.10		0.900			0.0002
3.0					0		1.00		3.99	0.0008	
3.2									4.25		
3.4									4.52		

graph which is close to zero. The user should satisfy himself as to just how far and how precisely he wishes to pursue this matter. It should be pursued until $\Sigma\Delta f \geqq 0.98$. It is in the last increments that the contribution of by-products may be greatest, and since any continuous reactor will produce over-reacted material, it may be wise to extend the calculation to $\Sigma\Delta f \geqslant 0.995$ so that a fairly accurate estimate of by-product production may be had. (2) If V is chosen small so that $\frac{q}{V}$ is large, the Δf column will add to 1.0 long before the concentration columns have been completed. This corresponds to a physical situation in which the contact time is short so that by-product formation is low. For an accurate estimate, the Δf column should be extended to larger values of $\frac{qt}{nV}$ by using the equations of MacMullin and Weber.

The second table is now prepared.

The sum of all the $(\Delta f)\ (\bar{c})$ columns is 0.9951, which is good enough. The result may be compared to the batch results at 0.75 hours, and it may be seen that the continuous process using three stages gave a product which differed materially from the batch process. If a closer approach to the batch result is desired, more stages would be required.

The calculation has some built in checks in that all the $\bar{c}$ values in each row should add to 1.00 and the sum of all the $(\Delta f)\ (\bar{c})$ columns should be 1.00. What with all the arithmetic being done, some small mistakes are inevitable.

This calculation is valid for either homogeneous or heterogeneous reactions in a reactor system whose residence time distribution is known and where there is perfect mixing in each reactor. It is not valid for a linear reactor (even if the residence time distribution is known), since the time history of molecules in regions of varying concentration cannot be known. If it is applied to a linear reactor, the results can only be regarded as approximate.

Design Group Needs Clear Data—During the course of any pilot plant development program, many unusual problems will be solved, and the experimenters may not be conscious of just how smart they were when they solved them. Since they are so familiar with the situation, it sometimes does not occur to them that everyone else does not know all about the problem. Therefore, requests for information from a design group may strike the experimenters as silly (to say the least). It is not silly! The designer is charged with the responsibility of designing and building a plant which will work and which can be built for the least possible amount of money. He wants his design to have as little uncertainty as possible, and in order to achieve this he must have good data. These good data are the responsibility of the development engineer; and he must not only take the data but he must present them in such a way that they can be used to design a larger unit.

The designer will call for information on any situation that is not already covered in the literature or in the designer's experience. Any new process—and it is usually for these that a pilot plant is built—will produce many kinds of peculiar process streams that have no counterpart in nature or previous process industry history. The physical characteristics of these streams cannot be calculated and the designer is perfectly within his rights to require the development engineer to measure the desired characteristic, correlate it with the process variables, and submit it in a clear, concise form.

In an interesting paper Michel, Beattie, and Goodgame[9] concluded that most types of engineering equipment do not need pilot scale tests and that the chemical aspects of a process will dictate the need for a pilot plant. The writer agrees with this statement but adds this: "If a pilot plant is built, the designer will call for equipment tests; and he is perfectly correct in so doing." The development engineers should anticipate this call, conduct tests on any situation which is novel, correlate the data, and be sure that the correlation is in such a form as to be suitable for design. What this means is that any piece of process equipment, no matter how familiar, may have to have engineering tests performed on it and the results correlated in some fashion.

TABLE 2—Calculating $(\Delta f)\ (C_t)$

t_2-t_1	Δf	$\bar{c}_R$	$(\Delta f)\ (\bar{c}_R)$	$\bar{c}_A$	$(\Delta f)\ (\bar{c}_A)$	$\bar{c}_B$	$(\Delta f)\ (\bar{c}_B)$	$\bar{c}_C$	$(\Delta f)\ (c_C)$
0.2-0	0.05	0.90	0.0450	0.10	0.0050	0	0	0	0
0.4-0.2	0.17	0.70	0.1190	0.290	0.0492	0.01	0.0017	0	0
0.6-0.4	0.21	0.508	0.1068	0.450	0.0945	0.028	0.0059	0	0
0.8-0.6	0.19	0.337	0.0640	0.598	0.1137	0.049	0.0093	0	0
1.0-0.8	0.14	0.196	0.0274	0.703	0.0984	0.106	0.0148	0.001	0.0001
1.2-1.0	0.10	0.086	0.0086	0.729	0.0729	0.194	0.0194	0.005	0.0005
1.4-1.2	0.06	0.020	0.0012	0.655	0.0393	0.312	0.0187	0.009	0.0005
1.6-1.4	0.03	0	0	0.498	0.0149	0.473	0.0142	0.015	0.0005
1.8-1.6	0.02			0.322	0.0064	0.640	0.0128	0.036	0.0007
2.0-1.8	0.015			0.149	0.0022	0.800	0.0120	0.083	0.0012
2.2-2.0	0.009			0.030	0.0003	0.820	0.0074	0.169	0.0015
2.4-2.2	0.003			0		0.670	0.0020	0.316	0.0009
2.6-2.4	0.001					0.490	0.0005	0.502	0.0005
2.8-2.6	0.001					0.300	0.0003	0.700	0.0007
3.0-2.8	0.0002					0.100		0.900	0.0002
						0			
Σ	0.9992		0.3720		0.4968		0.1190		0.0073

TABLE OF NOMENCLATURE

- $\underline{c}$ — concentration, wt. %
- c — average concentration, wt. %
- D — impeller diameter, ft. (in Reynold's number)
- D_v — diffusivity, ft.²/sec. (in Schmidt number)
- η_{OG} — fractional plate efficiency (overall) based on gas film
- f — fraction of liquid flowing held in a stirred tank reactor a time t or longer
- q — volumetric flow rate, cu. ft./hr.
- mG/L — ratio of slope of equilibrium line to slope of operating line
- N_G — number of gas film transfer units
- N_L — number of liquid film transfer units
- n — number of tanks in series
- n, N — revolutions per unit time
- P — power
- t — time
- V — reactor volume
- ρ — specific mass, lb. mass/cu. ft.
- μ — viscosity, $\frac{\text{lb. mass}}{(\text{ft.})\ (\text{time})}$

Subscripts

- P — plant scale
- E — experimental scale

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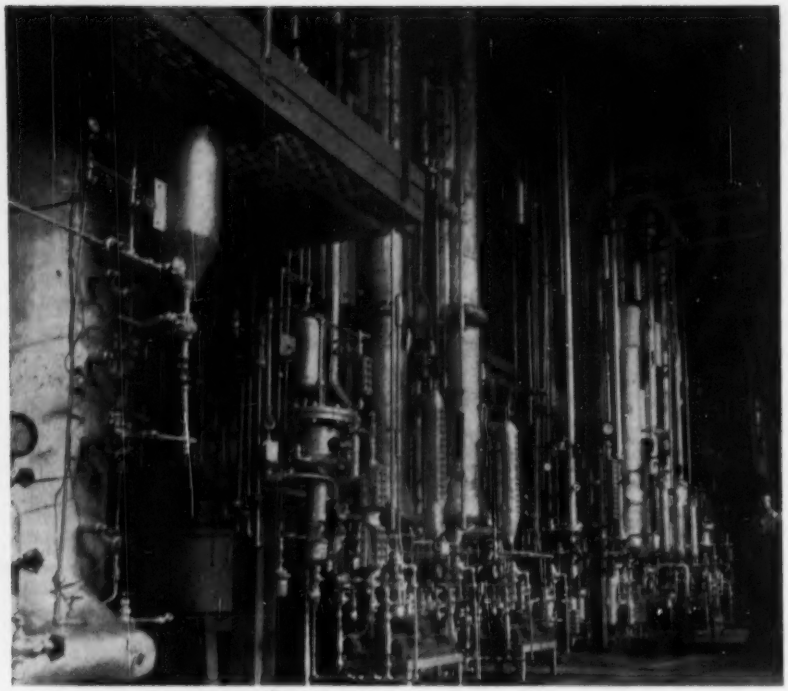


There's many a slip from this pilot plant to a commercial unit.

Research Problems

What to Avoid in Scale-Up

These traps in scaling up pilot plant data come from a survey of a large process development organization.

D. P. Thornton, Jr.
Universal Oil Products Company
Des Plaines, Illinois

THE OLD SAYING about "many a slip 'twixt the cup and the lip" very succinctly describes what can happen to the unwary designer of commercial processes when scaling up pilot plant data. Falling into just one of the many innocuous-appearing snares with which this work is beset conceivably can mean the difference between a workable process and a miserable failure or, perhaps, a process which can limp along if crutches are provided. Usually, the potentially disastrous effects of most of these traps can be minimized, if not entirely avoided, by the experience and caution of a well-trained, highly skilled engineering organization.

Many thorny problems are created and the effects magnified because of relative disproportionation among the various components which, together, constitute a "pilot" plant. This often comes about because the various items which may be selected in assembling the pilot unit are designed to provide the greatest practical flexibility and utility as a pump, a mixer, a reactor, a fractionator, a condenser, and so on. In some processes this may make no difference in the results obtained on either the pilot or commercial model. In many other instances, however, when components are not in proper balance with one another, all process variables are not necessarily under the control they may seem to be.

A "fluid" type catalytic processing unit can serve to illustrate the effect unbalanced pilot plant components may have in scaling-up to commercial size. Assume that the regenerator selected for the pilot unit is comparatively larger than the reactor. It has been designed for interchangeable use in a number of pilot units, as often is the case around research laboratories, and it was built to efficiently provide intimate contact between a fluidized catalyst and its regenerating medium, whatever either might be.

The first misstep for the designer might lie in the distribution of products in the reactor effluent. The uninitiated might well be deceived into believing that, with a given catalyst and variables such as charge and recycle rate, space velocity, temperature and pressure apparently well-controlled, product distribution will be the same regardless of the size of the unit. After proudly watching the commercial unit start-up, the designer may be dismayed no little to find a somewhat different product distribution than predicted by pilot data.

The designer could have been misled here because the pilot plant regenerator used was entirely too efficient, being comparatively larger than the reactor. Thus the regenerated catalyst quality in the pilot unit is not comparable to that obtained commercially. To scale up the pilot regenerator by the same ratio used for the reactor would have given an obviously too-large commercial unit regenerator, but the effect excess pilot regenerator capacity might have on the catalyst was entirely overlooked.

Similar effects may result from unrealized failure to control other process variables through unfortunate combinations in sizes of pilot unit components.

Side Reactions a Trap—Side reactions may occur in catalytic processes entirely outside and independently of the catalyst zone; they may be initiated thermally or be the consequence of the catalytic effect of materials of construction. A difference in their magnitude may result from the disparity in size between pilot and commercial unit.

Thermally-initiated side reactions like decomposition or polymerization may occur in heaters and transfer lines leading to or from the catalyst zone. The ratio of extent of these thermal reactions occurring respectively in the pilot and the commercial unit can be markedly different. The effect often depends upon the comparative vol-

umes of the lines, or the volume of lines with respect to the catalytic zone volume, comparative residence times, surface-to-volume ratios, and so on. The surface exposed in a pilot plant, in comparison to the volume involved, always is tremendously greater in the pilot unit than it is in the commercial version. This can prove extremely troublesome.

Catalyzed side reactions may have the same effect as thermally-initiated ones on the principal reaction involved. If the commercial unit is not to be constructed of the same materials used in the pilot investigation the designer should look for possible catalytic effects. Either thermally- or catalytically-initiated side reactions may hinder or enhance the reaction in scaling up; they also may prove insignificant. Therefore the designer must be continuously on guard against them.

Size Disparities to Be Watched—Size disparities between the pilot plant components and those of the commercial unit often may cause other unexpected effects. In fluidized beds of pilot units the maximum vapor velocity may be restricted to a few tenths of a foot per second because of the shallow bed. Maximum vapor velocity in a commercial unit 40-feet high bed may be of the order of two or more feet per second, however. This may or may not have a significant effect upon the reaction, but the point should be investigated before the commercial design is frozen for construction.

It is impossible to have a vapor bubble greater than 2 inches in diameter in the 2-inch diameter reactor vessel of a pilot fluidized catalyst unit. This is most certainly possible, however, in the probable commercial unit, where very large bubbles—several feet in diameter—can occur. The practical result of this obscure fact could affect the catalytic reaction in the commercial unit. It also has been known to produce hydraulic and dynamic phenomena requiring special mechanical design considerations as well as structural revisions to operating units in the field.

Size disparity may create unsuspected effects as the result of mass velocity in all types of catalytic beds. Although the pilot and a commercial unit both might have a liquid hourly space velocity of three, for instance, the mass velocity in the commercial unit can be many times greater than could possibly occur in the pilot unit. Hence the designer should make certain that the magnitude and direction of the effect is known if mass velocities are a significant variable in the reaction.

Problems which develop as a consequence of changing the so-called "L/D ratio" now are rather well known to the designers of commercial equipment. In the early days of catalytic processing, however, inexplicable results occasionally were obtained when a 2-inch diameter pilot reactor, say, was scaled up by a factor of 100, for example, and the bed length was jumped from the 5-inch pilot unit size by a factor of 20, thus changing "L/D." Eventually the mysteries were found to be variously attributable to channeling in parts of the bed, nonuniform distribution over the bed cross-section at the inlet, or top-to-bottom mixing.

These dimensional problems probably constitute the largest group of pitfalls besetting the path of the designer. They are particularly to be expected when scaling-up two-phase packed columns and in agitator-type mixing. Unfortunately, there is no "do-it-yourself" kit of solutions available. Even the experienced designer always should recognize that he is on treacherous ground in a radical scale-up involving these operations.

A sure but expensive way to avoid scaling-up problems as a consequence of "wall effects" due to size disparities is to use several successively larger intermediate-sized pilot units until it is evident that no wall effects exist or, if they do, the direction and magnitude of the influence upon the desired reaction are known. A considerable backlog of investigations and theorizing is available, however, from which probable wall effects may be calculated. An experienced, highly skilled engineering organization also has a wealth of diverse information available for its designers to draw on which permit still more reliance upon these calculations and minimizes the time which needs to be spent in pilot investigations.

Contaminants—Size discrepancy may also mask the presence of trace amounts of contaminants in the feed to a catalytic operation on the pilot plant scale. When the ratio of the area of vessel walls or transfer line surface, perhaps, to catalyst volume is quite high as it usually is in the pilot plant, some of the trace contaminants may "plate out" on the walls or be absorbed or trapped in some manner before reaching the catalyst bed. Unless the designer is aware of this possibility, perplexing poisoning effects in the commercial unit will be entirely missed in the pilot examination. Extending a process to a different feed than was used in laboratory investigations, or which has not been tried previously in commercial units, may be the mechanism of introducing the trace contaminants.

Arsenic poisoning of a reforming catalyst over a period of time in commercial use illustrates the effect of trace contaminants. This was first experienced in commercial operations, and was missed in pilot plants because the much greater metal surfaces on such units effectively removed the arsenic and protected the catalyst. In commercial units, the arsenic found its way to the catalyst, and separate removal means had to be provided.

A change in feed may be made by the process operator without consulting the designer or making an appropriate investigation and thus run the process into the contaminant problem. This is not the designer's fault, to be sure, but nevertheless he may be unjustly blamed and even "convicted" unless he is on his toes with the answer at the first hint of trouble.

The presence of contaminants as the consequence of construction and maintenance is an example. While this is in a sense a start-up problem often created by carelessness and not the fault of the designer, sometimes the reverse is true. Mill scale is a common problem in start-ups of catalytic processes, as it may have catalytic effects of its own, the results of which can be obscure. This will be discussed more fully later. Slugs of water, cleaning compounds, absorption oils and lubricants, among others, also may create unexpected difficulties. If a designer has reason to suspect that any of these can create difficulty with his process and it is not possible to design against them, he should at least issue a suitable warning and suggest protective measures in the start-up procedure.

Size effects likewise may mask the presence of trace amounts of materials in the product of a catalytic operation. A chemical company found this in the radical scale-up of a certain process,

a contributory cause reportedly being the unfortunate choice of analytical techniques which apparently failed to give a true quantitative picture of a certain by-product. When the commercial unit went into operation, unexpectedly large volumes of this material appeared. Its presence created not only a serious disposal problem during purification steps but a significant economic complication. Additional purification facilities had to be installed in this case so that this contaminant could be marketed; there was entirely too much to consider discarding it even if anti-pollution authorities would have permitted this.

Sampling itself may be a cause of trouble for the designer as well as the researcher because an equilibrium of some kind is so frequently a controlling or at least a directive factor in the reaction around which a process may be built. It shows up in pilot plant data because the removal of a representative sample large enough to yield the required analytical information may constitute a significant proportion of the stream in question, particularly in recycle types of operation. This can shift the equilibrium. The ultimate result then may be most serious and, too frequently, insidious. The possibility of securing misleading data should always be guarded against by adequate pilot plant investigation.

The inherent differences between the start-up procedures for pilot or laboratory equipment and the commercial unit can create unexpected difficulties with contaminants. Very often a pretreating reagent in the laboratory or pilot operation may be used in chemically pure form because it is handy, the amount required is relatively small or cost is of little consequence. Commercially-pure or even impure reagent may be necessitated in full-scale operations due to economic considerations or volume requirements. The effect sometimes can be startling and the designer should guard himself against falling into it.

Heat Effects—Heat effects may create serious problems for the designer of a commercial-sized unit because generally they will not show up significantly in the small pilot plant. Back in the early days of thermal cracking, for instance, there was no way to predict how long a commercial run could continue before coking in the heater tubes forced a shutdown. Despite pilot plant investigations, the rules of thumb thus developed often were wrong by a factor of five in either direction. To solve this and like problems it was once necessary to build pilot units which were almost on a par in size with small commercial units.

Endothermic and exothermic reactions usually pose no serious heat problems in the pilot plant because the ratio of vessel wall surface to reactor or catalyst volume permits heat to be readily conducted into or out of the vapors, or catalyst, as the case may be. The designer may stub his toe if he fails to adequately anticipate this in scaling up to commercial size, however, for here appreciable temperature lags are almost certain to develop.

Regeneration of fluid cracking catalyst is a case in point. Control of oxygen concentration in the regeneration process is not critical in the pilot plant and quite high oxygen concentrations in the flue gas are permissible. While the total heat released per unit volume may be identical both in pilot and commercial units, it is much more difficult to get heat *out* of the commercial unit, because of the greater distances over which it must travel. Thus, temperature may soar in the commercial regenerator to a level where the catalyst is damaged, or it is too high for the construction materials, or conceivably catalyst could be sintered and the maximum safe operating temperature exceeded for the vessel itself.

The commercial fluid cracking unit operator must maintain careful control of regeneration air at all times because of this reason. The designers of these units have used great skill in scaling up the regenerator from pilot plant data. Moreover, these units often are equipped with various devices to detect afterburning and facilities for bringing a temperature runaway under control. But excessive heat build-up in the regenerator still is a problem awaiting a fool-proof solution.

Getting heat *into* a catalyst bed so that it is uniformly distributed can be just as tough a problem as getting it out. UOP designers had to be on guard against endothermic heat effects in designing the first Platforming unit. Here the problem was that large masses of catalyst in the commercial unit could be rendered ineffective if the temperature got too low for the desired reactions to proceed. An interdependent problem was to supply all the needed heat at an optimum temperature level. Dividing the total catalyst mass into multiple beds and providing interbed heaters are two of the techniques which the UOP designers applied in solving these associated problems.

Metallurgy—Differences in metallurgy between the pilot plant and a commercial unit can and has brought designers considerable difficulty. These differences may not only affect the desired reaction by upsetting or completely changing product distribution but can cause unanticipated corrosion. Indeed, the presence of products of corrosion can further affect the desired reaction and require all sorts of investigations before the answer is ferreted out.

Pilot plant equipment often is constructed of more highly corrosion resistant material than would be used in building a commercial unit, partly for convenience and often for wide utility. Cost frequently is not a significant factor. These materials, perhaps aided and abetted by wall effects, may subtly affect product distribution by "promoting" or inhibiting the catalyst and thus seriously mislead the designer if he is not aware of this semingly innocuous possibility.

Bimetallic construction in either a pilot or a commercial unit can often lead the designer into trouble if adequate experimental work with suitable metallurgical help is neglected in the pilot investigation. The most frequent complication is the development of electrolytic corrosion effects, such as in tubular coolers where bimetallic tubing may be used to resist attack by dissimilar corrosive environments existing on each side of the tube wall. These materials also may be responsible for mechanical problems when specified for corrosion or high temperature resistance, such as stress corrosion, embrittlement effects and the like. They likewise may interfere with the reactions via the contaminants route as previously discussed.

The corrosion possibilities inherent in a process may be missed completely in pilot plant investigations because highly resistant materials may have been employed. Corrosion effects also can crop up due to the size disparity between the pilot and commercial units where different residence times,

fluid velocities and entrainment result in variable corrosion.

The effect of corrosion products on the course of a reaction thus may sneak up on both cub and experienced designer. These can be doubly misleading, perhaps because the pilot unit may have been built from such corrosion resistant materials that there were no corrosion products present. Corrosion products different from those found in the commercial unit may have been formed in pilot investigations to lead the designer astray.

Mill scale is a frequent offender in commercial units where corrosion resistant construction may have been used in piloting the reaction. The reverse has also caused much grief in that proportionately more mill scale or rust was present in components of the pilot unit and thus affected the reaction more than is experienced in the commercial construction.

Iron oxide may be reduced to finely-divided elemental iron in certain types of catalytic processes. It also may be at first reduced and subsequently converted to some compound. In any case it may have potent catalytic powers for the feed involved which may be totally at variance with those of the catalyst under study. Iron compounds are well-known "poisons" for certain types of catalytic cracking catalysts. Care is taken to keep mill scale from collecting in reactor sections of Platforming units to prevent undesired reactions from occurring before the charge contacts the platinum catalyst.

Recycle—Many designers have erred because they used data from a pilot plant which lacked all the components of a commercial unit. The recycle function, so often the makings of a competitive commercial process, sometimes is not adequately investigated in the pilot plant. Researchers often will attempt to argue that the result with recycling will be so obvious that confirmatory experimentation is unwarranted. The designer should let his judgment rule him in accepting this contention.

Research personnel prefer to omit recycling in pilot plant investigations with good reasons, for it always complicates the experiment even if it is so strongly desirable in the commercial unit. Trace contaminants, already discussed, may be introduced in recycling. It may cause trace contaminants to build up enough to affect the reaction significantly. Sampling becomes a problem with recycling. The withdrawal of even tiny amounts of internal streams can be most upsetting to reaction equilibria in a manner which investigator and commercial designer alike may not recognize until later, when the error may become expensive to rectify.

Recycling usually brings with it problems of inventory-to-fresh feed ratios in the pilot plant which tend to wash out in the commercial unit. This ratio usually is greater in the pilot plant than it will be in the commercial operation. Pilot research then may come to grief because inadequate time is allotted for the inventory to become lined out.

Entrainment—Measurement of entrainment effects always is more difficult in the pilot plant than in the commercial unit because of the relatively small quantities involved in the former. When entrainment is an important factor in a reaction, it is strongly advisable to reproduce commercial unit conditions as nearly as possible in the pilot unit.

Vacuum flashing of petroleum cuts illustrates the matter of measuring entrainment. The question which must be answered here is whether or not small amounts of certain materials are present in the overhead because of their volatility, or because they happened to be entrained in a much larger volume of vapor. If the latter is the case, as it often is, then the degree of entrainment to be expected in the commercial unit must be determined.

This matter may be made of any degree of complexity. For instance, differences in vapor velocities in commercial and pilot units as a consequence of size disparities can affect the degree of entrainment. Sampling, too, may have an effect upon the amount of entrainable material available in the pilot unit whereas it may be ignored in commercial practice. The accuracy of the answers obtained, and the foresight used by both researcher and designer, can have a very large bearing upon the design of the commercial unit and whether or not the process will meet performance guarantees.

The formidable list of things which can happen in scaling up pilot plant data to lead the designer astray should not make the reader wonder how any commercial unit was ever successfully designed. Mistakes were made and generally resulted in the recognition of some of the traps for designers which have been described here. They also are a clear warning of what can happen to the uninitiated.

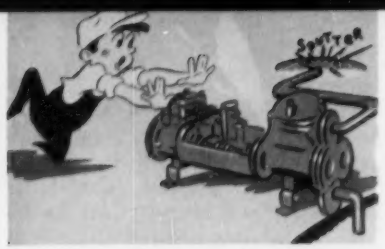
The successful designer of processing units is successful because he has acquired a large backlog of experience and the knowledge of how to use it to the best advantage of his client. This, in turn, permits shortcuts in research and pilot plant operation which reduce development time and expense between the birth of an idea and the construction of the first commercial unit embodying it.

Universal Oil Product's current practice is a good example of the shortcuts which over 40 years of experience permits. Very small pilot plants are used now. Most of them charge about 200 cc of total feed an hour while the largest runs on about one barrel of fresh feed daily. Scale-ups from such small units are feasible only because of countless correlations and knowhow which have been developed over the years.

The author is indebted to the research and development personnel of UOP for much of the information on which this article is based. ##

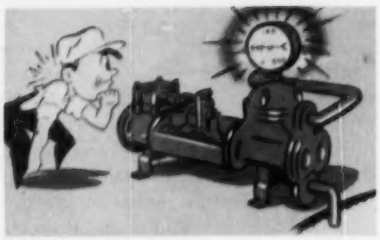
Meet the Author

DAVID P. THORNTON, JR., recently joined the staff of Universal Oil Products Company as technical assistant to the director of public relations. He has been connected with petroleum-industry publications for the past 15 years. Thornton joined the former W. C. Platt organization—later acquired by McGraw-Hill Publishing Company—in 1940 as market reporter for *Platt's Oilgram*. Two years later he was made manager of the Tulsa office of *Oilgram* and *National Petroleum News*. Later he was Southwestern editor of *Petroleum Processing*.



1. Failure to deliver required capacity may be caused by

- Lack of prime
- Insufficient speed
- Total dynamic head beyond pump rating
- Suction lift too high
- Air leaks in suction or stuffing boxes
- Foot valve clogged or too small
- Suction pipe not immersed deeply enough
- Liquid piston packing worn
- Liquid valves worn

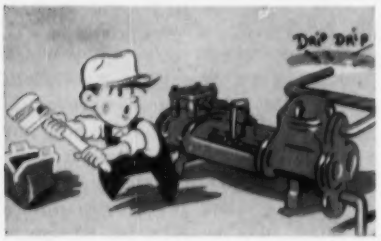


2. Pump fails to deliver required pressure —look for . . .

- Low steam pressure
- High exhaust pressure
- Worn piston rings in steam end
- Binding piston rings in liquid end
- Pump too small

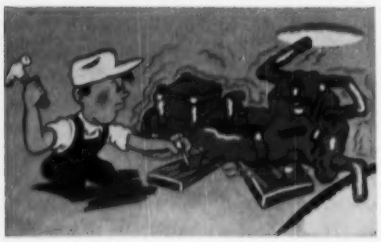
Steam Pump Trouble Shooting

If your pump is the correct size and has been properly installed, it will give you years of good service. But if you do run into trouble, here's what to look for.



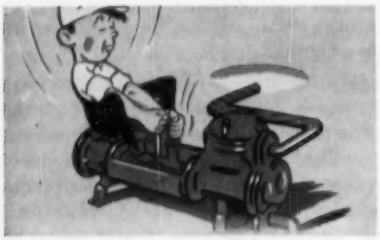
3. Pump loses capacity after starting—look for . . .

- Leaky suction line
- Suction lift too great
- Entrained vapors in liquid



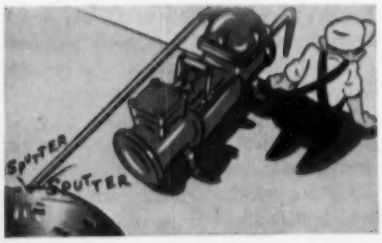
4. Vibrating pump may be due to . . .

- Misalignment
- Foundation not rigid enough
- Liquid piston packed too tightly
- Piping not properly supported



5. Pump has a tendency to short stroke—can be caused by . . .

- Liquid piston packing too tight
- Excessive steam cushioning
- Steam valves out of adjustment



6. Pump erratic in operation—check to see if . . .

- Any vapor trapped in liquid end
- Inadequate net positive suction head
- Pump is operating beyond its rating
- Drain valves connected together

These pictures were taken from a Worthington Corporation full-color strip film No. G-2280. The film can be obtained by writing to Advertising & Sales Promotion Department, Worthington Corporation, Harrison, N. Y.

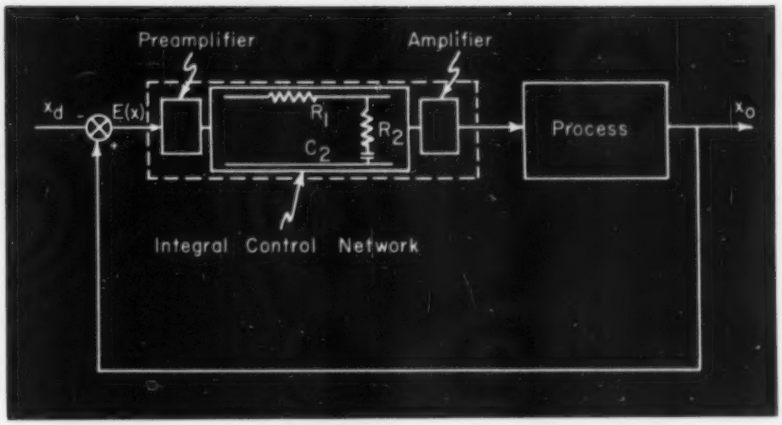


FIGURE 15—A typical nonideal derivative controller may be represented by a network of resistors and a condenser.

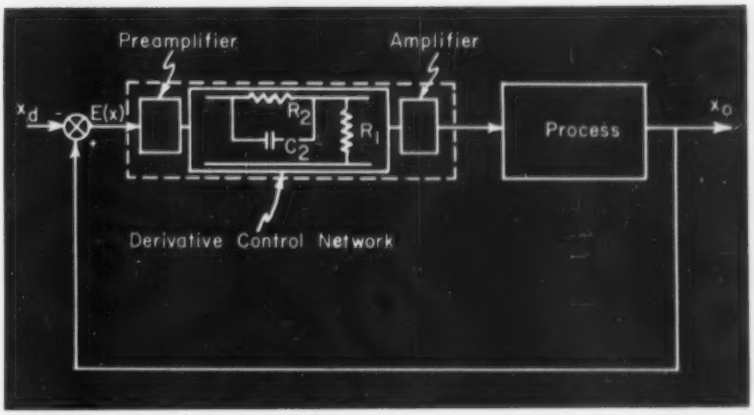


FIGURE 16—This diagram represents a typical nonideal integral controller.

Part 3

Automation Today

This article is the third of a series which is designed to acquaint the reader with some of the basic concepts of automatic control and their application to the operations of the petroleum and chemical industries.

There are several types of controlling mechanisms. In this part, the author describes these types and shows how they affect an example process.

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WE HAVE PREVIOUSLY described the various elements which make up the control loop and have shown how to determine the dynamic characteristics of the various refinery processes which are being controlled. We will now consider just how the correction computer part of the automatic controller performs its task and how the various elements of the control loop fit together, mathematically as well as physically.

CALCULATION OF CORRECTIONS

As we have previously mentioned, it is the duty of the automatic controller in a control loop to receive the error determined by the error detector. Then it treats this error in such a way that it computes the proper correcting action to be applied to the controlled process so as to nullify the effect of the disturbance which caused the original error. It might be said that the purpose of a controller is to apply a restoring disturbance to the process operation in such a manner as to correct the original disturbance which threw the process off specification. How is this accomplished?

There are three different methods which are commonly used in making error corrections. These are labeled as *proportional, derivative,* and *integral* control if one uses the nomenclature of electrical engineering.[12] In the nomenclature usually employed in the field of mechanical engineering[14] they are respectively *proportional, preact* or *rate,* and *automatic-reset* control.

These control methods may be used singly or in combination in applying automatic control to a process de-

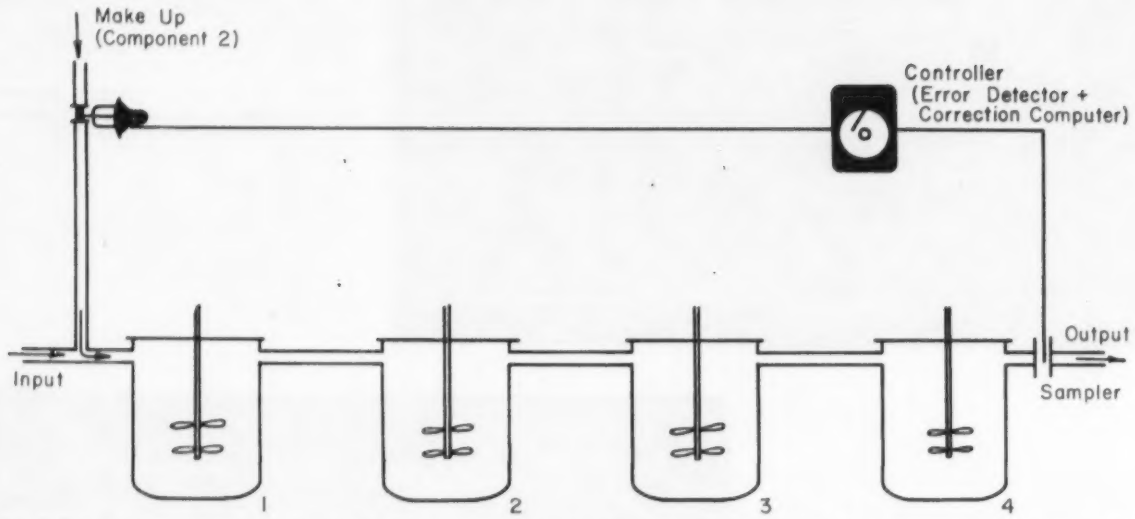

FIGURE 17—It is assumed that this system will add a component 2 to an input mixture of component 1 and component 2 in order to enrich the output.

pending upon the complexity of the process and the degree of control desired.

Proportional control can be readily summarized as follows: the correction applied is equal to some constant times the original error. For example, in distillation the variable which is monitored might be either the distillate composition or a plate temperature, and the flow rate which is altered to apply a correction to the column operating conditions might be the distillate take-off rate. Therefore with proportional control the required change in distillate take-off rate would be some constant times the error in the distillate composition or some other constant times the error in plate temperature. In symbols

$$\Delta D = K\,E\,(x_D) \tag{25}$$

where

$$E\,(x_D) = x_D - \overline{x_D}$$

or

$$\Delta D = \overline{K}\,E\,(T) \tag{26}$$

where

$$E\,(T) = T_d - T_o.$$

Here $\overline{x_D}$ is the desired distillate composition and x_D is the actual value measured. Likewise, T_d is the desired plate temperature and T_o is the actual temperature on the plate.

For any particular column or other piece of apparatus being controlled there is one value or small range of values of the proportional contant K or $\overline{K}$ which gives an optimum correction. Too small a value of K results in an excessive continuous or steady-state error, while too large a value results in instability or repeated overcorrection of the controlled variable. Since an error of some magnitude must always be present for a ΔD to exist, proportional control can never completely correct an unbalance in the output of the column. This necessary remaining error is called the *steady-state error* of the system.

The term *proportional band* is sometimes used in connection with the proportional constant. This is defined as the percentage of the maximum allowable variation in the output function which is necessary to cause a complete movement of the basic control element of the process such as the distillate take-off valve of our example. Thus a proportional band of 100 percent would be roughly equivalent to a proportional constant of one while a proportional band of 10 percent would be equivalent to a proportional constant of 10 and so forth.[12]

Derivative control, preact, or rate control involves a correction which is equal to some constant times the derivative of the error in the output variable being measured. For our chosen distillation example this may be symbolized as

$$\Delta D = K' \frac{d\,E\,(x_D)}{dt} \tag{27}$$

In the operational calculus notation introduced in the previous article

$$\Delta D = K'\,p\,E\,(x_D) \tag{28}$$

Derivative control is sometimes very helpful since it can detect a change in the value of the output function and apply a large correction while the error is forming rather than waiting until the error itself has become large as would be the case with proportional control.

Dervative control is never used alone but only in combination with other methods.[13] This is due to two reasons:[7] First, because of its mathematical nature it can only correct a changing error, a large but steady error would therefore generate no correction since its derivative would be zero. Second, it is very difficult to accurately evaluate the derivative of a physical process, particularly if the control device is electrical, because of the effects of *noise*.

Noise is the accumulated effect of variations in the measured output variable due to such things as inhomogeneities in external conditions of temperature and pressure, and small variations in the operation of the instrument

itself. Most of these variations are of short duration and thus have large and rapidly varying derivatives.

Integral control gives a correction equal to some constant times the time integral of the error. Thus

$$D = K'' \int_0^t E\,(x_D)\,dt \qquad (29)$$

In the calculus, integration bears essentially the same relation to differentiation as multiplication does to division in algebra. That is, they are opposite functions. This point is recognized in the operational calculus by the following definitions:[9]

$$p \equiv \frac{d}{dt}, \qquad (30)$$

$$\frac{1}{p} \equiv \int dt. \qquad (31)$$

Thus in operational calculus notation, Equation 29 would appear as follows:

$$\Delta D = \frac{K''}{p} E\,(x_D) \qquad (32)$$

This is a very common type of control due to its property of being able to eliminate all error since the correction will be integrated to a larger and larger value as long as any error is present. Thus there is no steady-state error as in proportional control. However, should the output variable then change in magnitude so that the error develops a change in sign, the accumulated correction must be integrated out before the proper correction can be applied. Thus integral control alone is quite sluggish in operation and can easily lead to overcorrections and thus an oscillatory response in the process being controlled.

The term reset-rate is sometimes used for an integral constant, K″.[14] Reset-rate is defined as the number of times per minute full travel of the controlled element, such as the distillate takeoff valve in our example, can be caused by the maximum allowable error of the output. As mentioned previously, this terminology is common in mechanical engineering circles. Since time in electrical terms is based upon the second, a reset-rate of one corresponds to an integral constant of 1/60 or 0.0167.

Theoretically derivative and integral control used together should make a very good combination since the anticipatory nature of the derivative control would help in eliminating the accumulated correction of the integral control following a variation in the error. However in practice this is not always possible due to the difficulties already mentioned in applying derivative control.

The complete correction can be expressed mathematically for the general case by adding the contributions of each of the possible types of control. Thus for an error derived from distillate composition,

$$\Delta D_T = K\,E\,(x_D) + K'p\,E\,(x_D) + \frac{K''}{p} E\,(x_D). \qquad (33)$$

In practice no instruments are available which can give a completely exact derivative or integral of the process output error. The use of the terms K′p for derivative control and K″/p for integral control refer only to the ideal cases. Therefore we must develop an equation for expressing the actual function developed by the controller as an approximation to the true derivative or true integral.

An equation frequently used for an actual derivative controller is

$$\Delta D = \frac{k' \propto (\tau p + 1)}{(\tau \propto p + 1)} E\,(x_d), \qquad (34)$$

again using our distillation example. For small values of $\propto$ and τ this expression resolves itself into a combination of proportional plus pure derivative control.

An actual integral controller can be readily expressed by the equation[12]

$$\Delta D = k'' \frac{(\tau p + 1)}{\tau \beta p + 1} E\,(x_D). \qquad (35)$$

Now for large values of β, Equation 35 becomes equivalent to a combination of proportional plus pure integral control.

As we must be able to vary the values of τ, $\propto$, and β to accomplish the results to be discussed in the next section of this paper let us consider how these values may be derived. Although an electrical network will be used, similar relations may be derived from consideration of equivalent pneumatic systems.

A typical nonideal derivative controller is pictured in Figure 15. The correction is calculated by the network with the equation constants being determined by the following relations:[12]

$$\tau = R_2 C_2, \qquad (36)$$

$$\propto = \frac{R_1}{R_1 + R_2} \qquad (37)$$

The amplifiers increase the signal from the error detector and counteract the attenuation or reduction caused by the network. They thus provide the value of the gain, k′. If R_2 is made a potentiometer or other variable resistance, we have a method for varying the values of τ and incidentally of $\propto$ as needed.

A commonly used nonideal integral controller is pictured as Figure 16. The constants of Equation 35 are derived by the following relations using the components of this network:[12]

$$\tau = R_2 C_2 \qquad (38)$$

$$\tau\beta = C_2 (R_1 + R_2) \qquad (39)$$

Again the amplifiers supply the gain, k″. Variable values of τ and β can be obtained again by making R_2 a variable resistance. In these calculations R represents the resistance in megohms and C represents the capacitance in microfarade.

CONTROLLER EFFECTS UPON A PROCESS

We will now investigate the effect of various controller actions upon process dynamics and show how the controller accomplishes its purpose. For purposes of illustration let us assume we have the system given in Figure 17, which is to be used to enrich a lean mixture of components 1 and 2 to a uniform level for later use in another process. This is, of course, a more complex system than would normally be used for such a purpose but is necessary to discuss our point adequately. Further let us assume that for some reason it is impractical to sample anywhere except at the output of the system. We are now faced with a system with four large time constants represented by the capacities of the four mixing kettles in series. As we discussed in a previous article, the differential equation describing this situation when expressed in operator notation is

$$\frac{x_o}{x_i} = \frac{1}{(\tau_1 p + 1)\ (\tau_2 p + 1)\ (\tau_3 p + 1)\ (\tau_4 p + 1)} \qquad (40)$$

As before, $\tau = \frac{C}{F}$, where C is the capacity of the vessel

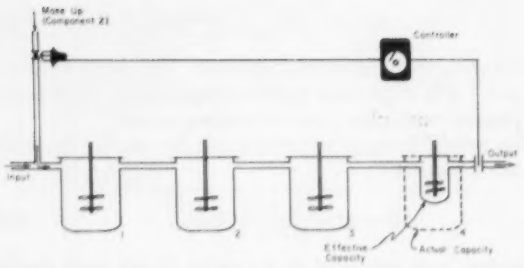

FIGURE 18—A derivative controller has the same effect as reducing the capacity of one of the mixers.

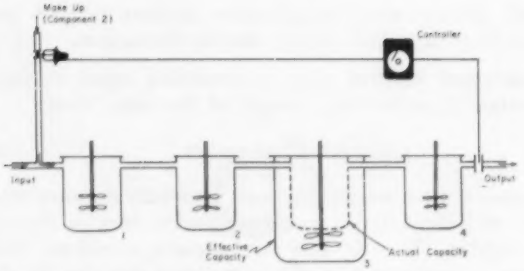

FIGURE 19—An integral controller has the same effect as increasing the capacity of one of the mixers.

in question and F is the input flow rate to the vessel. τ therefore has the units of time. Since we are going to correct the value of x_1 by a variation of the component 2 flow rate we need a relation between the change in input composition, $\triangle x_1$, and the change in makeup flow rate, $\triangle F_2$. If $\triangle x_1$ is small a linear relation can be considered to hold. Thus

$$\triangle x_1 = M \triangle F_2 \quad \text{or} \quad \frac{\triangle x_1}{\triangle F_2} = M \tag{41}$$

where M is a constant. $\triangle F_2$ must itself remain small to avoid a significant change in the main flow rate of the process, F, and thus a change in the value of the time constant, τ.

When derivative control is used, the relation between E (x) and F that is generated by the controller can be expressed as

$$\triangle F_2 = \frac{k' \propto (\tau_c p + 1)}{(\tau_c \propto p + 1)} E(x)$$

or

$$\frac{\triangle F_2}{E(x)} = \frac{k' \propto (\tau_c p + 1)}{(\tau_c \propto p + 1)} \tag{42}$$

Here E (x) is again the error sensed in the output by the error detecting apparatus of the controller. We must now develop the relation between $\triangle x_o$ and E (x) to describe completely the recovery of the system from this detected error. This can be done by multiplying together the various elements of the system we have already developed.[12] Thus

$$\frac{\triangle x_o}{E(x)} = \frac{\triangle F_2}{E(x)} \cdot \frac{\triangle x_1}{\triangle F_2} \cdot \frac{\triangle x_o}{\triangle x_1}$$

or in the form of the complete equations

$$\frac{\triangle x_o}{E(x)} = \frac{k' \propto (\tau_c p + 1)}{(\tau_c \propto p + 1)} \cdot M \cdot \frac{1}{(\tau_1 p + 1)(\tau_2 p + 1)(\tau_3 p + 1)(\tau_4 p + 1)}$$

$$\frac{\triangle x_o}{E(x)} = \frac{M k' \propto (\tau_c p + 1)}{(\tau_c \propto p + 1)(\tau_1 p + 1)(\tau_2 p + 1)(\tau_3 p + 1)(\tau_4 p + 1)} \tag{43}$$

Again our ability to do this depends upon the system being linear or a very close approximation thereto.

Now if we have made the proper choice of our derivative controller elements so that $\tau_c = \tau_4$, then Equation 43 reduces to

$$\frac{\triangle x_o}{E(x)} = \frac{M k' \propto}{(\tau_c \propto p + 1)(\tau_1 p + 1)(\tau_2 p + 1)(\tau_3 p + 1)} \tag{44}$$

Since $\propto$ is a number much less than 1.0, the composite time constant $\tau_c \propto$ represents a kettle of very much less capacity than formerly and thus the result of the controller action is to greatly speed up the response of the system. Figure 18 illustrates this effect.

The result of the choice of the proper combination of proportional plus *ideal* derivative control would be to completely eliminate the effect of one of the capacities of the system.

If integral control were applied, the equation for describing the ability of a system to recover from an error is given as follows:

$$\frac{\triangle x_o}{E(x)} = \frac{k''(\tau_c p + 1)}{(\tau_c \beta p + 1)} \cdot M \cdot \frac{1}{(\tau_1 p + 1)(\tau_2 p + 1)(\tau_3 p + 1)(\tau_4 p + 1)}$$

or

$$\frac{\triangle x_o}{E(x)} = \frac{k'' M}{(\tau_c \beta p + 1)(\tau_1 p + 1)(\tau_2 p + 1)(\tau_4 p + 1)} \tag{45}$$

if the proper choice of τ_c is again made.

Since β is a number much larger than 1.0 in contrast to $\propto$, the result of this operation is the replacement of one of the capacities of the apparatus with another which is much larger. This means that the response of the system will now be much more sluggish, there will be an effective integration action since the correction will be applied for a longer time, and likewise the chances of evershoot and a resulting oscillation will be increased. Figure 19 describes this effect.

An ideal or near ideal system will show these same effects but to a lesser degree. A combination of ideal integral and proportional control

$$\frac{F_2}{E(x)} = K + \frac{K''}{p} = \frac{\tau_c p + 1}{\tau_c p} \tag{46}$$

would result in effective elimination of one capacity element, but the addition of the integrating element $\frac{1}{\tau_c p}$. Thus the system would still be much slower than the ideal derivative system. Its comparison with the original system would depend upon the value of τ_c.

This type of an analysis succeeds in pointing up the undesirable aspects of integral control without adequately describing its desirable features. It is often entirely satisfactory, however, to accept a slowing up of the system in order to secure the elimination of all steady state error by the integrating effect of this type of control. In fact, this elimination of error is many times absolutely necessary.

# #

End of Part 3. Part 4 will appear in an early issue.

Midget Plants—and How They Grew

1. Claytonville Plant . . . Portability Was Not the Goal.

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Sweetwater, Texas

THE CLAYTONVILLE gasoline plant is actually one of three "midget gasoline plants" ranging in design capacity from 2 to 5 MMscfd capacity, designed and constructed by the author and associates. These plants are of the compression-refrigeration type designed to produce gasoline, LPG mixture and propane. The Coker Gasoline plant in Coleman County, having 2 MMscfd capacity and the Claytonville plant in Fisher County with 3.7 MMscfd compressor capacity and 5 MMscfd process capacity are owned and operated by the group. The third plant was constructed on an engineering contract for another operator in Coleman County who had previously installed gas compressors.

These plants were not constructed with portability as a goal. They are automatic to the extent of normal controls for the attended operation planned.

The flow diagram of all three are essentially the same and similar to those widely recorded in literature. The gas gathered at 10 pounds per square inch gage or less from field separators and treaters is scrubbed and compressed to 500 psig. The gas stream is cooled with air and/or water then protected with injection of diethylene glycol for refrigeration to approximately zero degrees F. The condensate, glycol and residue are separated at this temperature. The residue is used to precool the incoming stream before passing to sales. The glycol is discharged to a reconcentrator. The hydrocarbon condensate is processed in two bubble tray columns. The methane and ethane are removed in the first column, part of these vapors being used for fuel with the balance to residue sales. The second column, referred to as a stabilizer, is used to produce three streams; gasoline from the bottom, LPG from a side drawoff several trays above the feed point, and propane vapor is withdrawn overhead. The propane is condensed and part of the condensate is returned as reflux, the balance going to storage. The lower part of the column is refluxed by LPG from the drawoff tray through a bypass and the excess is removed through use of a level control on the drawoff tray. The products are cooled and sent to storage.

The differences in equipment in the three plants are primarily due to economical sizing of individual units. Scarcity of water was a fundamental consideration in design of these plants so air or evaporative condensors were used to minimize water consumption where feasible.

The Coker plant employs two gas engine driven two stage gas compressors, purchased assembled with gas intercoolers, scrubbers, belt drive, etc. Refrigeration is supplied by a 10 x 10 ammonia compressor system driven by a gas engine. Evaporative condensors are used for ammonia condensing, gas aftercooling and product cooling. A direct fired glycol reboiler is used for concentrating the glycol while salt bath indirect heaters are used with gravity flow through coils for heating column bottoms.

Decision to build is based on these factors:

1. **Reserves**
2. **Composition of gas and recovery**
3. **Marketing**
4. **Plant costs**
5. **Operating costs**

The horsepower requirements at Claytonville plant for compression of gas and refrigeration were such that two 550 horsepower integral compressors with 5 gas cylinders each could handle both duties satisfactorily. The gas is compressed through three stages while the propane refrigerant passes through two stages. The compressors were not pre-assembled or packaged though each compressor is individually piped with its own aerial cooler and scrubbers. The aerial cooler fans are driven off the compressors and provide three stages of gas aftercooling as well as jacket water and lube oil cooling. Each compressor represents half the total compressor load resulting in maximum flexibility. A gas engine driven single stage compressor is used to compress residue to 800 pounds-per-square-inch sales pressures.

A natural draft cooling tower provides cooling water at Claytonville plant for refrigerant condensing, some gas after cooling and final product cooling. A separate aerial fintube cooler is used to condense propane vapor off the stabilizer.

The heat medium used is heat transfer oil circulated through a direct fired tubular heater and then to reboilers at the base of each column and to the glycol reboiler.

This brief description of the equipment used at the Coker and Claytonville plants is presented to illustrate that even in "midget plants" a thorough appraisal of the economics of each part of the plant may justify considerable difference in choice of equipment. Ammonia refrigeration has proved very satisfactory at the Coker plant in original cost and low maintenance cost whereas propane refrigeration using integral compres-

Midget Plants Report

Claytonville Plant . . .

sors for both gas and refrigeration compression at Claytonville was most economical. The belt driven gas compressors have given only a normal amount of trouble commensurate with the investment and certainly have their place in the field of "midget plants."

The balance of this paper will be devoted to the Claytonville plant. The plant products are 26 RVP gasoline, butane-propane mixture of vapor pressure to suit the needs of local dealers, and commercial propane. For plant performance information, the streams have been varied from 14 to 26 RVP gasoline and butane-propane mixtures from 60 to 120 RVP.

Product specification control has been little problem. The gas stream is sweet and the products require no treating or sweetening. Plant tests consist of running vapor pressures on each product and an LPG weathering test every four hours. The mercury freeze test is run on propane daily. The cobalt bromide moisture test on propane is run periodically. A weekly test of the neutralization number and viscosity of lube oil and oxygen content of engine stack gases is recommended laboratory procedure for proper maintenance of good compressor operations.

The Claytonville plant operation is automatic to the extent that for all pressures, temperatures and liquid levels, controls are provided. Anything which would tend to keep the plant running full time is provided to the best of the ability of the designers. Normal safety and shut down devices are provided. There is no elaborate shut down or alarm system integrated in the plant control.

Specifically the Claytonville plant is equipped with automatic devices for the following operations:

1. Liquid level control on inlet and interstage scrubbers.
2. Compressor suction pressure regulator.
3. Speed governor on compressors.
4. Liquid level controls on all separation equipment.
5. Pressure control on gas stream, deethanizer and stabilizer and fuel system.
6. Temperature control on transfer oil and glycol reboiler with recording temperature controllers on the deethanizer and stabilizer bottom product and the LPG drawoff tray.

The plant is equipped with the following safety and shutdown devices:

1. High-level mercoid shutdown on inlet scrubber and interstage scrubbers.
2. Over speed, high jacket water temperature and low oil pressure shutdown on engines.
3. Relief off the residue gas line ahead of booster compressor.
4. Low suction and high discharge pressure shut down of booster compressor.
5. Normal relief valves for pressure vessels and lines in the plant.
6. Safety shutdown on the heater actuated by failure of circulation of oil to maintain proper pressure differential across the heater flow coil.

The one manually controlled process step is that of adjusting reflux rate to the lower part of the stabilizer. Adjustment of this rate is infrequent.

Automatic alarms to a remote area or integrated shutdown devices were not considered economically justified in this plant. Product sales by truck require almost constant attendance at the plant although the actual loading time is not great. By having one operator per shift it is possible to handle the marketing and plant operations as well as normal maintenance. The operator is usually able to correct the difficulties that would lead to a plant shutdown if unattended and thus avoid costly downtime.

Portability of the plant was given little consideration at Claytonville, partly due to the life expectancy of the field and due to the analysis of costs of the plant subject to portability. The compressor piping as well as that in the process area is such that it could be reassembled in another plant about as easy as that of the package plants. The installation costs of this plant including all the labor, supervision, foundations, trucking and erection of the compressors and process equipment represented less than 8 percent of the total plant cost.

Of this cost, a portion of the labor, supervision and essentially all the

Table 1

Design Economics Based on Percent Potential and Revenue

Cost Items	Case 1 Recover gasoline, residue gas	Case 2 Recover gasoline, residue gas, butane	Case 3 Recover gasoline, residue gas, butane, propane
Gathering System	15.8%	15.8%	15.8%
Compressor Station	40.7%	42.4%	42.4%
Process Equipment	20.6%	29.2%	29.9%
Marketing & Storage	3.1%	4.2%	10.5%
Land & Improvements	1.4%	1.4%	1.4%
Total	81.6%	93.0%	100.0%
Percent of Cost Saved	18.4%	7.0%	0.0%
Percent Revenue	51.9%	74.9%	100.0%

foundation, trucking and erection cost would be lost in any movement of the equipment. Almost all the compressor piping and a part of the process piping was prefabricated in the field while foundations and other necessary work preparatory to receiving equipment was done.

Approximately 60 days elapsed between the starting of foundations and plant operation. These results substantiated the conclusion that it would not have been economical to have invested in extensive prefabrication from standpoint of cost, portability or construction time.

The factors governing the success of "midget gasoline plants," though much the same as in larger plants, must be given even closer scrutiny in many instances to allow one to walk the "economic tightrope." These factors in the order of importance are:

1. A thorough evaluation of gas reserves available to the plant and just as thorough study of the rate at which the reserves will be made available.
2. Composition of gas and expected recovery must include evaluation of these factors over the life of the reserve; as well as seasonal effects which can also be important.
3. Marketing evaluation is as complex and as demanding as other factors and precludes the thought that recovery of product is enough. This requires study of general market trends, local trucking market, rail facilities, crude oil or product pipe line market, geologic possibility of underground storage and certainly road conditions to the plant site. Gasoline plant possibilities are nearly always found in areas of existing plants where the new venture will sharpen the competitive battle yet could lend to cooperative efforts toward underground storage where feasible. In the Southern states, the sale of propane in the summer necessitates tank car or product line movement north while in the north, butane sale is equally troublesome in the winter.
4. The study of plant cost involves the study of each part with all the logical alternatives examined in order. The plant cost must consider the various marketing possibilities. An example of the consideration to be given a plant design may be gleaned from Table 1 based on the Claytonville plant.

Items of cost are tabulated percentage wise against the choice of a plant to recover (1) gasoline and salable residue gas only, (2) gasoline, residue and butane and (3) gasoline, residue gas, butane and propane. The percent of potential gross revenue is shown also. Case 3 represents 100 percent cost and revenue.

This illustrates in a stream rich in butane and propane, the need to recover and market these products. At Claytonville plant a very low temperature refrigeration type plant to recover maximum propane was indicated.

5. Operating costs naturally follow the determinations of design, recovery and marketing.

Thorough evaluation of these factors should finalize the design including the degree of automation and portability desired and allow reasonable prediction of the financial success of a "midget gasoline plant."

##

Meet the Author

W. W. PYEATT is vice president of Claytonville Gasoline Company and manager of its natural-gasoline plant at Sweetwater, Texas. Except for a year or more which he spent as manager of Paraffin Melting Service at Kilgore, Texas, he was with Black, Sivalls & Bryson, Inc., in various engineering and sales positions from 1939 to 1954. He was administrative assistant to the vice president and manager of engineering when he left B. S. &. B. to join Claytonville Gasoline. Pyeatt is a petroleum-engineering graduate of Texas A & M College.

2. Ropes Plant . . . Low Volume, Rich Gas With a Long Life.

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Honolulu Oil Corporation
San Francisco

PRODUCTION in the Ropes field is owned by Honolulu Oil Corporation and Signal Oil and Gas Company. These two companies decided it was feasible to design and construct a plant which economically would conserve and process Ropes gas. The volume of gas available for processing was slightly less than 2000 Mcf per day. This small quantity of gas, even though relatively rich, made it imperative that both capital and operating costs be kept to an absolute minimum. The expected long field life, however, of something greater than 20 years, required that only the best of materials and equipment be used. In addition, to meet pipe line residue gas specifications, it was necessary that the residue gas be substantially dehydrated and that at least 65 percent of the propane in the wet gas be recovered, together with practically all of the heavier hydrocarbons. Because there was no rail facility in the immediate area and because there was no pipeline outlet for any of the plant products, it was necessary that the plant be designed to recover, fractionate, and load plant products which could

FIGURE 1—Ropes plant: On-stream performance is 98.76 percent.

be utilized in the truck transport market.

To keep expenses, both operating and maintenance, to a minimum, and to keep capital costs as low as possible, processing techniques were required which would:

1. Eliminate the use of electricity for everything except noncritical, intermittent, uses such as plant lighting, product loading, and starting air compressor.
2. Eliminate boilers or vaporizers, steam or otherwise, operating at a pressure greater than 15 psig.
3. Reduce the necessity of water treating to a minimum.
4. Utilize the expansion of fuel gas to drive all pumps not driven directly from the compressor engine.
5. Provide for high liquid product recovery at all loads and fractionate the product so recovered into 95 percent purity propane, 80 to 125 pound vapor pressure LPG-mix, and 12 to 26 pound Reid vapor pressure gasoline.
6. Provide for delivery of dehydrated residue gas at 500 pounds.
7. Provide substantially automatic operation, with personnel required only for the essential duties of plant maintenance, plant office, product testing and product loading.
8. Provide for stable, reliable, and inherently safe operation, with a high service factor plant.

For the requirements of this particular field, economics dictated the choice of a refrigeration-condensation type plant. With three stages of gas compression (from atmospheric pressure to 500 psig) and one stage of refrigerant compression, four compressor cylinders were required on each compressor unit if the gas and refrigeration loads were to be balanced. With a total requirement of about 660 horsepower, the use of more than one compressor would have required tandem cylinders on each unit to handle both gas and refrigeration loads. Therefore, only one gas engine driven compressor unit with three stages of compression, plus a refrigeration cylinder, was installed. The jacket water pump for this unit and

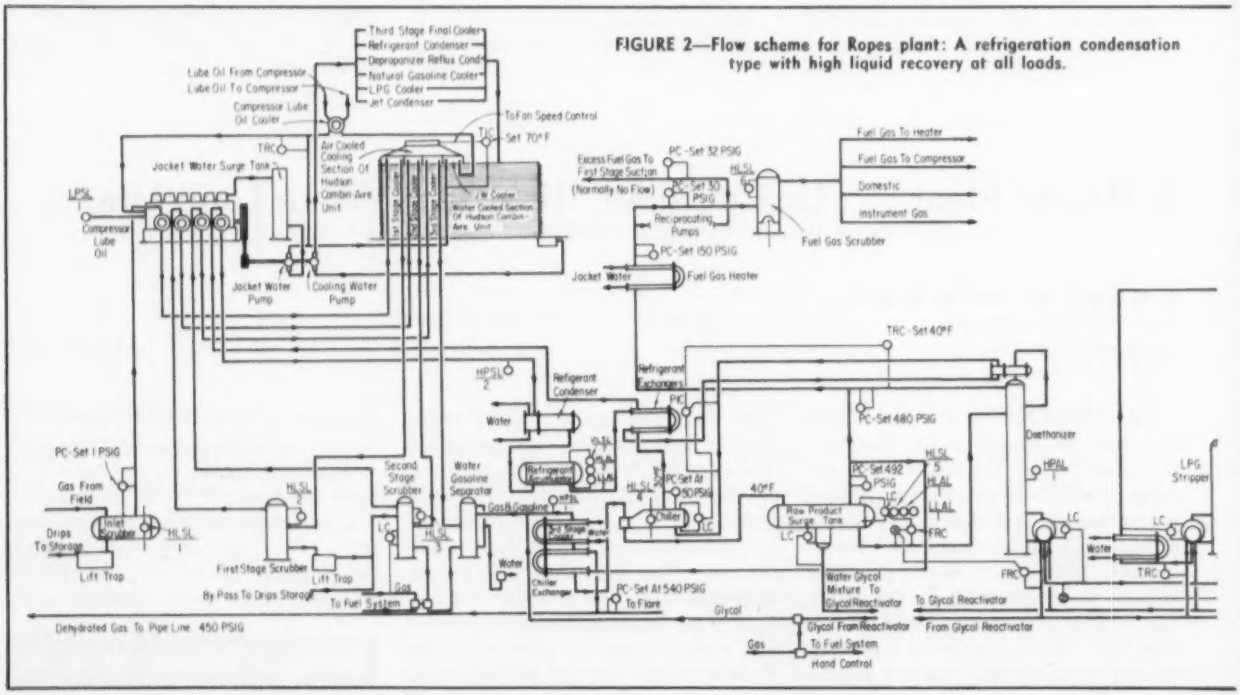


FIGURE 2—Flow scheme for Ropes plant: A refrigeration condensation type with high liquid recovery at all loads.

the plant cooling water pump are both V-belt driven from the compressor engine. Through a torque tube arrangement, which is visible in one of the pictures, the cooling tower fan is also driven from this engine.

The master meter on the plant inlet stream, for economy, utilizes a pitot-venturi element for measuring flow. Between the inlet scrubber and the first stage suction header, a butterfly valve actuated by two pilots controls pressure as follows: One pilot acts to prevent a vacuum on the gathering system, and the other pilot serves to keep the compressor suction pressure from rising to a value which could seriously overload the compressor engine. First, second and third stage discharge gases and jacket water are air cooled in the air section of the cooling tower. This section, utilizing air which has previously passed through the water cooling section, is designed to cool the gases to 100 F. when ambient air is 105 F. This tower has one induced draft fan which, as mentioned, is driven from the compressor engine. The fan has controllable variable pitch blades, with the pitch adjusted by a temperature controller located on the third stage discharge gas from the air cooler. The pitch of the fan can actually go about 10 degrees negative, if need be.

Jacket water, as shown on the flow diagram, is temperature controlled, using a bypass arrangement, and is used to cool compressor engine lube oil. Water from the water cooling section of the tower is circulated through shell and tube units for the remainder of the plant cooling duties. With this arrangement, only low temperature streams are cooled with water and as a consequence, scaling of equipment is negligible.

Because the inlet scrubber is at substantially atmospheric pressure, any inlet scrubber condensate is lift-trapped to drip storage. First stage condensate also moves by lift trap to the second stage scrubber. Second stage condensate from the second stage scrubber is pumped to the water-gasoline separator, where it is commingled with the third stage compressor discharge stream which has been air cooled. At this point, all water which has been condensed is drained.

After removal of water, glycol is injected into the stream to prevent hydrate formation. Then, after water cooling and after heat exchange with the cold gas from the raw product surge tank, this stream passes into the chiller, where it is chilled to about 35 F. From the chiller, the stream then passes to the raw product surge tank for separation.

From the raw product surge tank, uncondensed and dehydrated hydrocarbons (sales gas) pass through the chiller-exchanger to the sale gas pipeline. Water-glycol mixture is removed from the surge tank and passes to the glycol regenerator. Hydrocarbon condensate (raw product) is fed to the deethanizer and is flow controlled with a flow controller which is reset by a liquid level controller located on the raw product surge tank. Pressure on the raw product surge tank is held sufficiently high to cause the raw product to flow, without pumping, to the deethanizer.

In the deethanizer, ethane and lighter hydrocarbons are fractionated overhead and enter the fuel gas system. The deethanizer is held at a pressure higher than the sales gas pipe line pressure so that any overhead gas which is in excess of fuel gas requirements will join the gas stream from the raw product surge tank and flow to the sales gas pipe line.

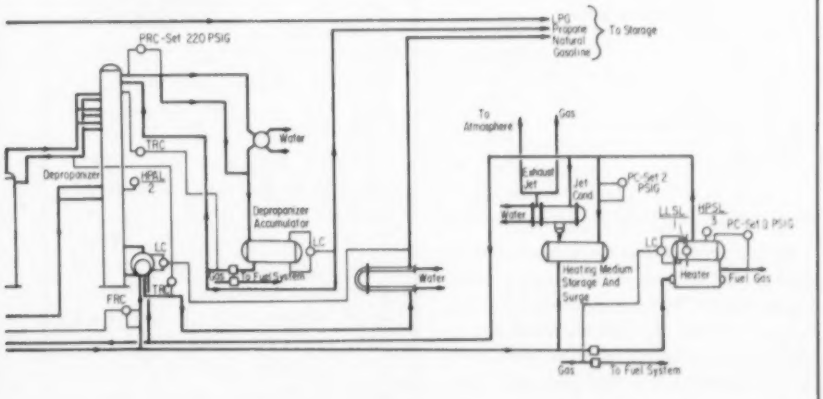
The deethanizer is a packed tower and is fed at the column top. The reflux condenser is mounted above the column and all hydrocarbons condensed therein are returned to the column as reflux. Deethanizer overhead is chilled in the reflux condenser to 35 F. which is substantially the same temperature as hydrocarbons from the chiller. The entire refrigerant stream passes through the deethanizer reflux condenser before going to the chiller with the deethanizer top temperature controller acting to reset a pressure controller located on the refrigerant stream between the deethanizer reflux condenser and the chiller. Reboiler heat medium (para-cymene) is flow controlled with this flow controller reset by the flow controller located on the deethanizer feed stream.

Propane and heavier fractions from the deethanizer pass into the depropanizer, a 40-tray column, for fractionation into 95 percent propane as an overhead product, 14-pound Reid vapor pressure gasoline as a bottom product and 100-pound vapor pressure LPG-mix as a side-cut product. The latter is further fractionated in a side-cut stripper.

Top temperature of the depropanizer is controlled with a temperature controller by regulating the reflux pump. Para-cymene from the depropanizer reboiler is flow controlled. This flow controller is reset by the flow

NOMENCLATURE

LC	Liquid Level Controller	LLSL	Low Level Shutdown And Light
PC	Pressure Regulator	HLAL	High Level Alarm And Light
PRC	Pressure Recorder Controller	HLSL	High Level Shutdown And Light
PIC	Pressure Indicator Controller	HPAL	High Pressure Alarm And Light
TRC	Temperature Recorder Controller	HPSL	High Pressure Shutdown And Light
FRC	Flow Recorder Controller	LPSL	Low Pressure Shutdown And Light
LLAL	Low Level Alarm And Light		



Midget Plants Report

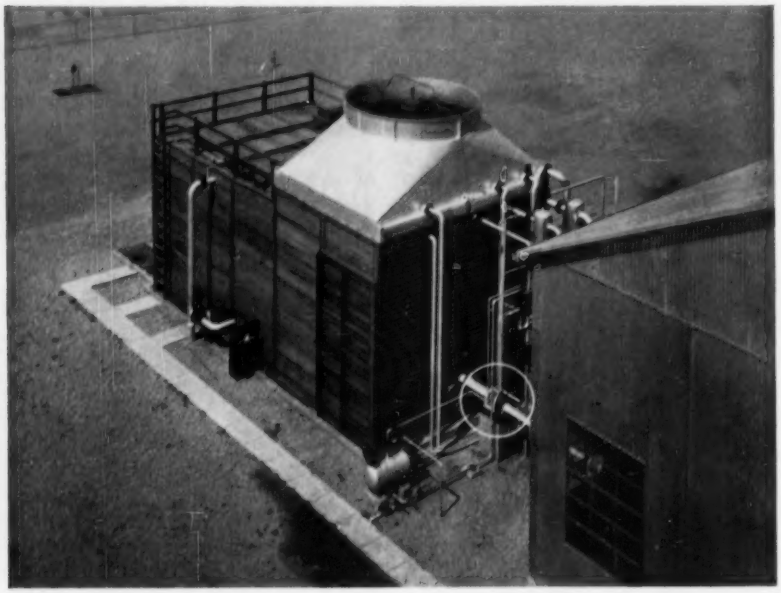


FIGURE 3—With torque tube arrangement, cooling tower fan is driven from compressor engine.

controller on the depropanizer feed. Temperature of the depropanizer base is controlled by a temperature controller which regulates the rate of feed to the side-cut stripper. Temperature of the base of the stripper is, of course, controlled by a temperature controller regulating stripper reboiler heat medium.

Propane is used as the refrigerant in the plant. After one stage of compression it is condensed in a water cooled condenser and collected in the refrigerant accumulator. From the refrigerant accumulator, it flows through the refrigerant exchanger, then through the deethanizer reflux condenser to the chiller shell. The flow is regulated by a level controller on the chiller. As previously mentioned, a pressure controller, reset by a temperature controller, controls the pressure (and therefore the temperature) of the propane through the deethanizer reflux condenser. From the chiller shell, propane vapor passes through the refrigerant exchanger to the refrigerant compressor cylinder. The refrigerant exchanger serves the dual purpose of conserving horsepower and insuring that any liquid propane which might possibly be carried over cannot reach the compressor cylinder as liquid.

Para-cymene is used as the heating medium in the plant. A two-drum vaporizer is used to varopize the material and operates at a pressure of approximately 8 psig. This system, although not exactly conventional, has been extremely satisfactory in its performance.

All pumps, other than those driven directly from the compressor engine, are reciprocating and are driven by the expansion of fuel gas. Fuel gas from the deethanizer, at 475 psig, is heated (by jacket water) and expanded to 150 psig. As much gas as is required then passes through the power ends of the pumps to the fuel gas system, which is held at about 30 psig. Any additional fuel gas required is vented directly to the fuel gas system through a pressure regulator.

TABLE 1
Ropes Gas Is Rich

	Mol Percent
N_2	7.04
C_1	40.22
C_2	13.98
C_3	20.60
iC_4	3.08
nC_4	8.14
iC_5+	6.94
	100.00

In addition to the usual plant safety devices, an extensive alarm and shutdown system has been provided. This system warns of unusual changes in plant operation by sounding an alarm in the plant and in the resident operator's home and it also indicates by lights on a panel the location of any unusual changes. In addition, the system shuts down the plant and holds it safe until readjusted and restarted if the unusual change increases and whenever such action is necessary to protect plant equipment or personnel.

The alarm panel has its electrical components so arranged that only the original source of trouble can sound an alarm and turn on a light, unless the reset button on the alarm panel is pressed. When the reset button is

Meet the Authors

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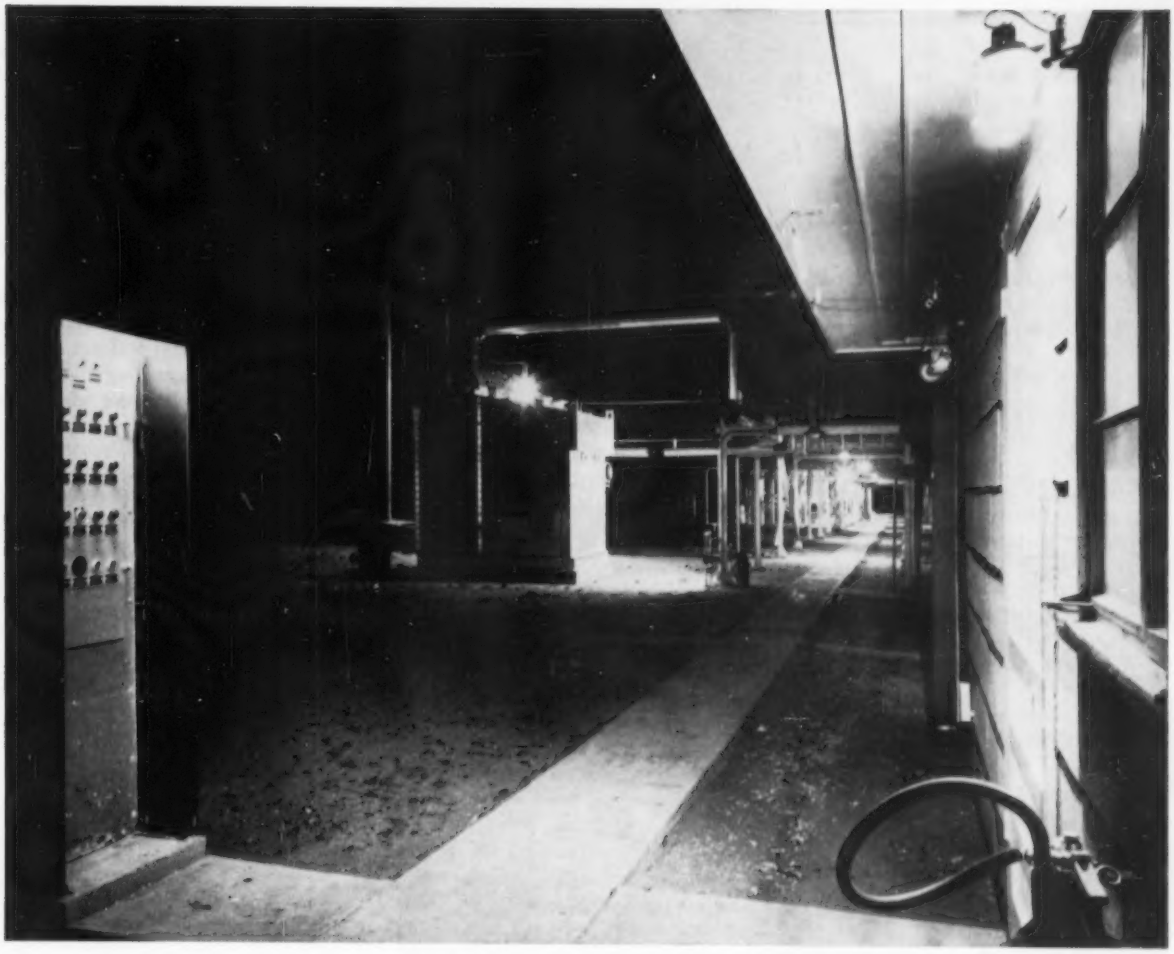

FIGURE 4—Alarm panel (left): Only the original source of trouble can sound an alarm and turn on a light until reset.

pressed, any other alarm device which has been actuated also turns on a light, thereby enabling the operator to distinguish between the condition causing the original alarm and any other subsequent happening which may require correction.

The shutdown mechanism is extremely simple. For reliability, it is separated electrically from the alarm system and is battery powered. It works by:

1. Grounding the compressor engine magneto.

2. Actuating a three-way valve which closes off the gas used in the instrument pneumatic system and vents to atmosphere any instrument gas in the instrument system. This causes all motor valves to fail in a safe position, including a motor valve which shuts off fuel gas to the compressor engine. This particular motor valve requires manual resetting so that the instrument system can be put back into operation without fuel gas pressure existing on the compressor engine until such time as the operator is ready to re-start the engine.

The various shutdown and alarm points are listed below:

Shutdown and Alarm Points

Compressor Engine

High jacket water temperature,
Engine overspeed,
Low lube oil pressure.
(There is only one light on the alarm panel for all of these devices.)

Level

Inlet scrubber high level,
Second stage suction scrubber high level,
Third stage suction scrubber high level,
Chiller high level,
Raw product surge tank high level,
Fuel gas scrubber high level,
Refrigerant accumulator high level,
Para-cyment heater (vaporizer) low level.

Pressure

Third stage discharge high pressure,
Refrigerant discharge high pressure,
Para-cyment heater (vaporizer) high pressure.

Alarm Only Points

Level

Raw product surge tank high and low level.
Refrigerant accumulator, high and low level.

Pressure

Deethanizer high pressure.
Depropanizer high pressure.

Midget Plants Report

Ropes Plant . . .

In addition to the above points, a manual emergency shutdown button is provided on the alarm system panel located adjacent to the plant near the plant gate.

Operating History—One measure of any plant venture is its operating history. The Ropes Plant which has been in operation for approximately three years has shown the following on-stream performance percentages:

1953	99.25%
1954	98.19%
1955	98.76%

From inception, the entire plant force has consisted of one chief operator and two operators. In addition, one relief operator has been regularly utilized one shift per week and has also worked sickness and vacation schedules. Any additional maintenance or repair help required has been drawn from the district headquarters located some 25 miles from the plant. To date, overtime requirements have averaged less than 60 hours per man per year and assistance by personnel from the company shop has averaged less than 16 man hours per month.

The field is shut-in semi-annually for 72 hours, for bottom hole pressure measurement. This time is not included in the above on-stream compilation. During these periods, all possible maintenance and repair is performed. Such periods are excluded from the on-stream time compilation above, since the plant cannot operate during these periods of no field gas production.

Primary duties of the plant crew comprise the following:

1. Operation of and routine maintenance on plant equipment.
2. Product loading of all products into tank trucks, including preparation of run tickets.
3. All routine analyses required, including water and plant product streams.
4. Field chart changing (seven-day charts) and the calculation of gas volumes therefrom.
5. Operation of and maintenance on field meters.
6. Preparation in pencil of all monthly plant and production reports. These reports are then checked and typed as necessary in the district office by clerical personnel. This district office clerical labor has averaged about four man hours per month.

It was hoped that the plant design would permit one operator to start the plant without assistance and put it on stream in a minimum of time, without undue effort. It has been found in practice that after a 72-hour shutdown, one operator can bring the plant from no-flow to specification products, in three hours. Less than one and one-half hours of operator time is required during this period.

The alarm and shutdown system incorporated in the plant was designed to be a reliable and extra safe system, which the operating personnel would be very desirous of having in continuous operation. In the three years of its history, there have been three failures of the alarm and shutdown system itself:

1. An electrical short in a lead to the shutdown and alarm panel.
2. Hydrate formation in a bourdon tube of a pressure alarm. (This has since been prevented by the addition of glycol once per year.)
3. A faulty switching device. (This device has since been re-designed by the manufacturer.)

The operators are not only satisfied with the alarm and shutdown system, but have found it so reliable and helpful that any indications of mal-function are given top priority for checking and repair.

Plant recovery has averaged ten gallons of total liquid product per Mcf of inlet gas. Typical component recovery percentages, together with temperature and pressure data are shown in Table 2.

TABLE 2

Raw Product—Deethanizer Operation

Raw Product Surge Tank:	
Pressure, Psig	500 Psig
Temperature F.	35 F.
Percent of Rich Gas Condensed:	
C_3	82.0%
iC_4	92.9%
nC_4	93.5%
iC_5+	98.2%
Deethanizer:	
Pressure, Psig	465 Psig
Feed temperature, F.	36 F.
Overhead to Reflux Condenser, temperature °F.	112 F.
Dry Gas temperature F.	38 F.
Bottom temperature F.	259 F.
Percent of Feed Retained:	
C_3	85.9%
iC_4	97.7%
nC_4	98.3%
iC_5+	99.5%
Over-all Plant Recovery:	
C_3	70.5%
iC_4	90.7%
nC_4	91.9%
iC_5+	97.7%

Hudson Engineering Corporation designed and constructed the Ropes Plant for the Signal Oil and Gas Company and Honolulu Oil Corporation, who have found that the plant performance has completely met all their expectations and requirements.

##

3. Stroud Plant . . . Portability With Easy Construction.

Otha H. Grimes
Tulsa

PORTABLE PLANTS involve an additional cost for the skid unit or units on which the equipment is mounted. This cost is offset by simpler foundation construction and generally less foundation concrete requirements. There are other cost factors in field-constructed plants which, when included with the foundation item, we believe substantially exceed the skid cost. The portable plants require substantially less

"know-how" on the part of the field erection personnel.

They are frequently sold to, and erected by, production people who are not particularly skilled in gasoline plant construction and who especially welcome the erection simplicity. There is an absolute minimum of field labor required. The intricate process piping is complete when the plant units are received in the field.

The skid unit process piping is prefabricated and stenciled, and this eliminates the possibility of field mistakes and confusion. The piping work done in the shop is performed by a crew perfectly familiar with the work, and therefore is done more efficiently and more economically than would be the case in the field. As may be observed, the cost of this equipment can be pre-determined. Also the salvage value of such plants is high. Obviously, there is a minimum of loss in materials, welding and labor when such a plant is moved.

These units have been designed for maximum simplicity consistent with efficient operation. Many of these units have been applied to comparatively high-pressure gas processed at up to 1000 pounds and higher and where the residue gas is delivered to a gas transmission system and the processing pressure therefore depends upon pipe line pressure.

The Stroud, Oklahoma, plant described here involves a more or less conventional absorption-distillation cycle with several special features that contribute to the goal of maximum simplicity. The fundamental skid unit ideas involved herein can be, and have been, applied to various processes, such as absorption combined with very low pressure dry distillation, and processes not using absorption oil at all but using gas fractionation and refrigeration. This Stroud plant, however, is more conventional, involving a main absorber operating at 300 pounds pressure, a reabsorber operating just below still pressure, the still operating at a pressure between 100 and 125 pounds, and product fractionators consisting of the usual deethanizer, depropanizer and debutanizer, for the production of three streams—natural gasoline, a butane-propane mixture and propane. In this particular plant all of the pressure vessels are mounted on a single skid.

The complete skid unit also includes process pumps, fractionator reboilers, control equipment, scrubbers, reflux separators, etc. Heat exchange equipment, except for reboilers, is separately skid-mounted. The oil heating furnace is set up at a safe distance outside the hazardous area. In this particular plant, a combination of air cooling and water cooling is used, air cooling being applied to the high temperature-level duties and to engine jacket water cooling.

Several of these plants have been built with a single fractionator to produce only natural gasoline. With a single fractionator the plant is exceptionally simple and may be operated by the usual field production personnel, and unattended a large portion of the time. Such plants are particularly applicable to those proj-

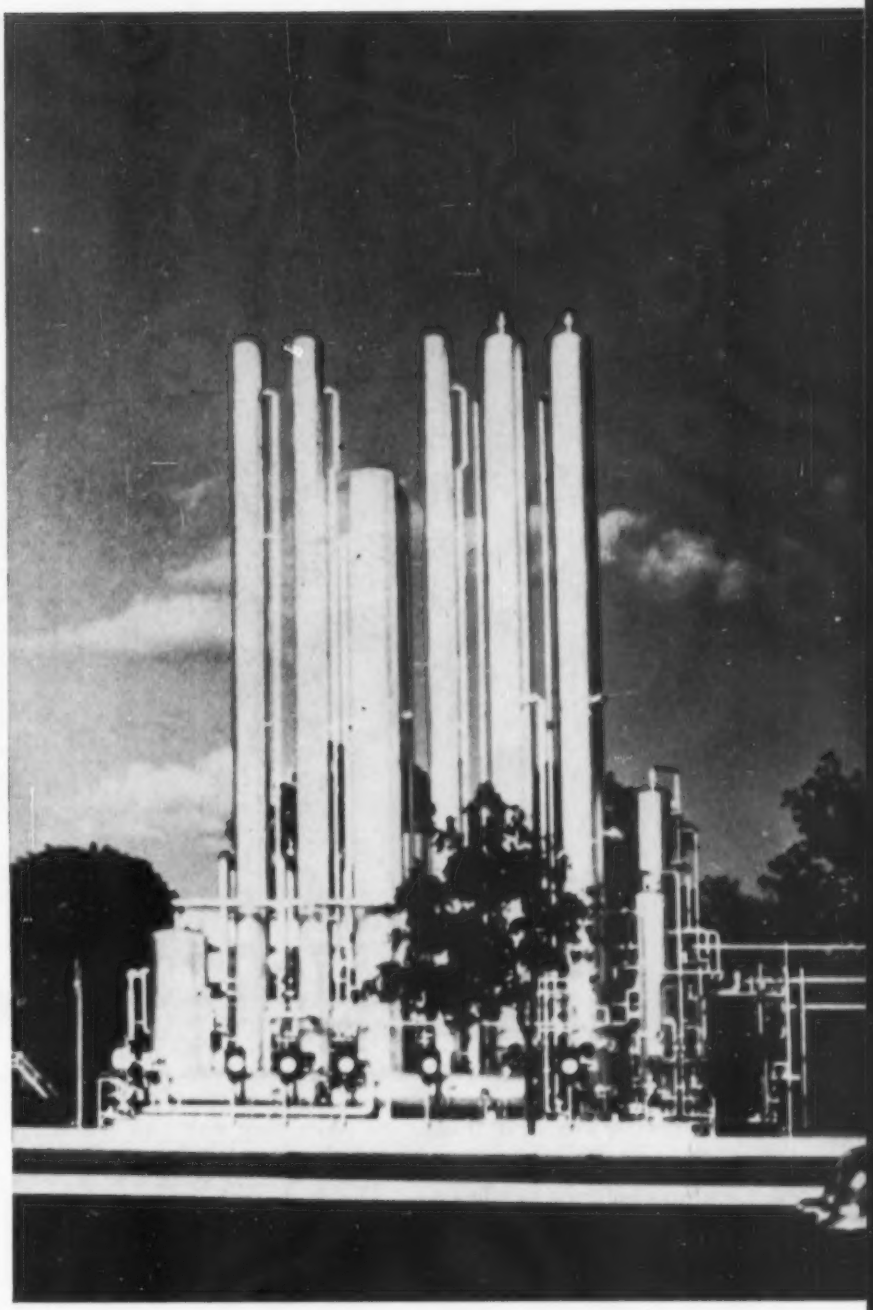

FIGURE 1—Stroud Plant: A conventional absorption-distillation cycle with several special features.

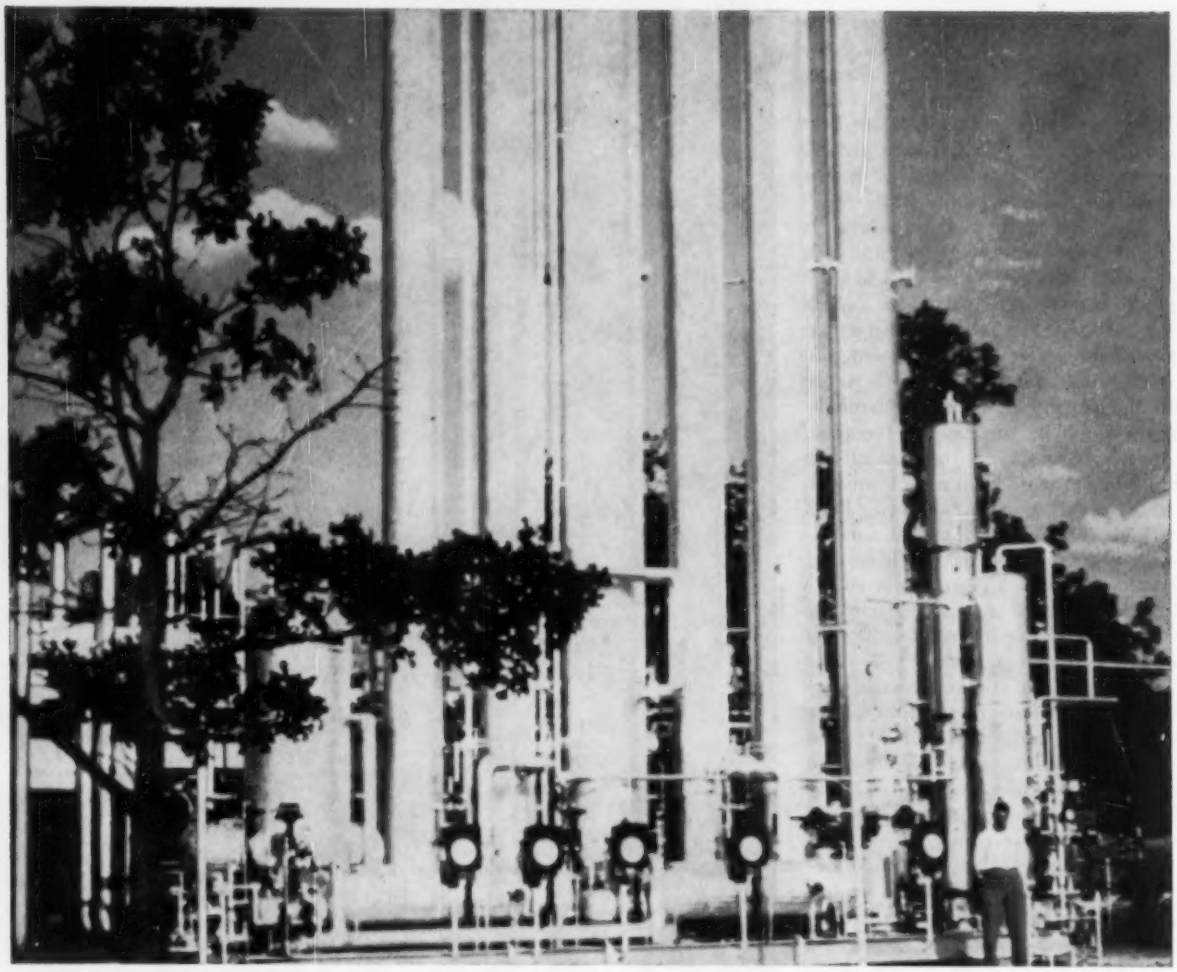

FIGURE 2—All the pressure vessels are mounted on a single skid.

ects where the gasoline production is delivered to a crude oil pipe line system and mixed with the crude and where an attendant is not made necessary for truck loadings.

One of the important items simplifying the operation of these plants is the heating arrangement. The heat required for the entire plant is furnished by a single oil furnace. This furnace pre-heats the rich oil stream entering the still. The rich oil stream is usually heated to about 500 F. The lean oil stream leaving the base of the still is used to supply other process heat requirements. First, a controlled portion of this stream passes through pipe coils in the bottom of an evaporator unit mounted on the skid. This is used to evaporate water, providing process steam for the still. This is the only steam used in the plant. There are no boilers. Second, the hot lean oil stream passes to fractionator reboilers, preheater, and power gas heater and then back to the absorption oil exchangers.

As previously mentioned, steam is used in the ordinary manner for stripping in the still, and this steam comes from the evaporator heated by the hot lean oil stream. This evaporator operates in a closed system. Since it is not fired, traces of hydrocarbons in the water fed to the unit are unimportant. The still has a conventional water draw-off tray in the upper section. The water from this tray is returned directly to the evaporator. This water return is operated without any control equipment, simply by the separation of water from still reflux hydrocarbons at the water draw-off tray and a seal arrangement in the draw-off line. The pressure at the evaporator is slightly higher than the pressure at the water tray, the evaporator operating at still base pressure. Since the water tray is elevated, gravity returns the water to the evaporator nicely; the stackup in the draw-off line being in accordance with the pressure difference.

For simplicity, a common condenser is used for raw product and still reflux. The condenser outlet materials pass to a separator tank from which the uncondensed hydrocarbons are released back to the reabsorber. The reflux pump receives a mixture

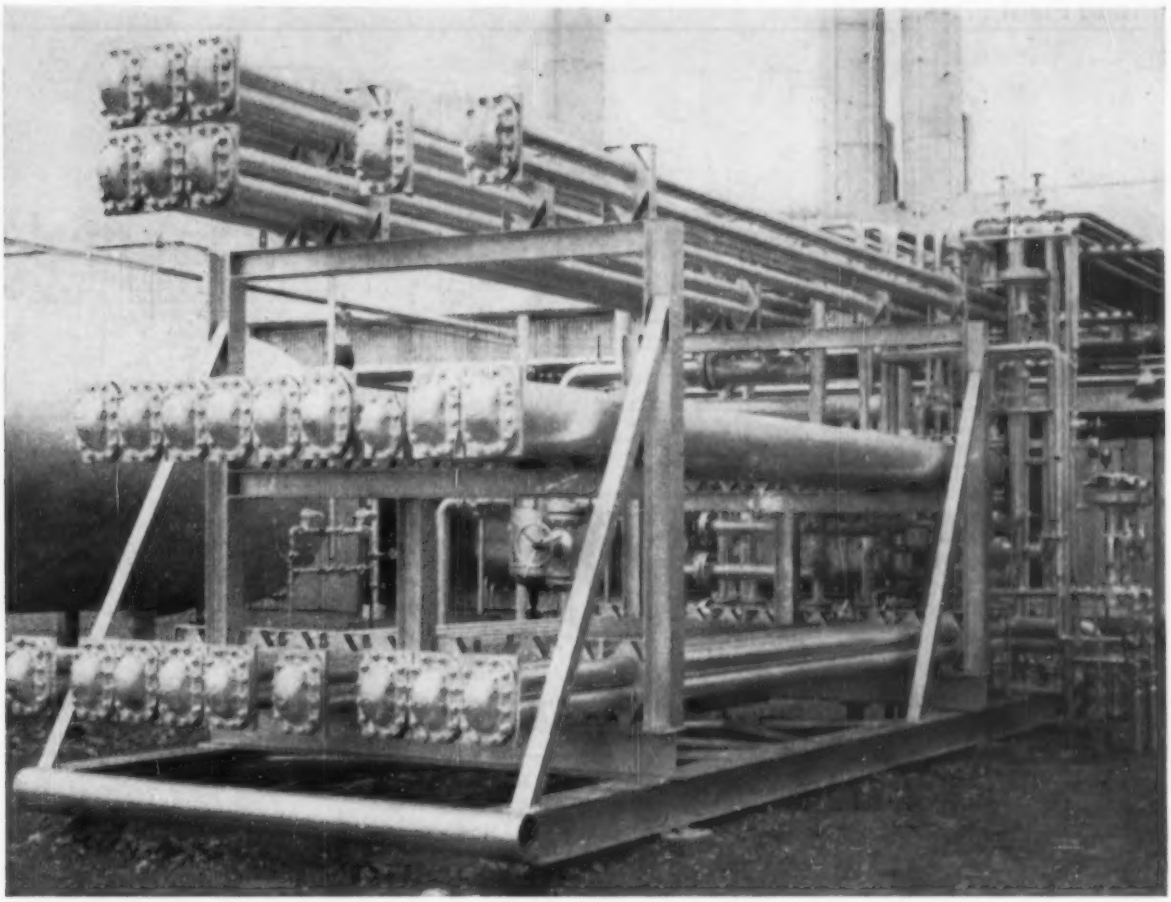

FIGURE 3—Heat exchange equipment (except for reboilers) is separately mounted.

of hydrocarbons and water from the bottom of this tank and discharges this mixture to another tank located below the separator. This second tank operates at a pressure high enough above still pressure to deliver reflux to the top of the still and water to the process steam evaporator. This tank separates hydrocarbons from water, the water stream being controlled by a dual gravity liquid level controller.

The tank normally operates full of liquid. Still reflux passes from the top of the tank through a temperature controlled valve back to the top of the still. With this arrangement the still reflux pump does double duty, serving as a feed pump for the still process steam evaporator as well as still reflux pump. The water returned to the evaporator by gravity and the water handled by the still reflux pump combined constitutes the water used to produce process steam. A small amount of makeup water is occasionally added to compensate for water that leaves the system dissolved in the liquid hydrocarbon streams.

The stills for such plants are built with greater space than usual below the bottom tray. This space serves as lean oil storage. No liquid level controller is used at the base of the still. Lean oil passes from the base of the still through the heat supply system, as previously mentioned, to the oil heat exchangers and oil coolers. A small pressure settling tank is usually installed between the lean oil coolers and pump. Water is drained from this tank and released to a sump where, together with makeup water, it may be pumped to the process steam evaporator. A single lean oil pump is generally used, serving both the main absorber and reabsorber.

Rich oil from the high-pressure absorber is released to the reabsorber a few trays above the bottom. The reabsorber tower serves as flash tank as well as absorption tower. Uncondensed vapors from the still pass to the base of the reabsorber. This arrangement results in a substantial reduction in the methane and ethane present in the raw make. It is necessary to pump rich oil through the exchangers and furnace to the still since the reabsorber operates at a pressure slightly below still pressure. A back pressure regulator on the reabsorber regulates the distillation unit pressure.

The Stroud plant uses a minimum number of pumps. The lean oil pump is an engine driven reciprocating power pump. The reabsorber rich oil pump and the still reflux pump are electric motor-driven centrifugal pumps. The remainder of the process pumps are reciprocating pumps of the "steam pump" type. After being heated in a hot lean oil exchanger, fuel gas instead of steam is used as

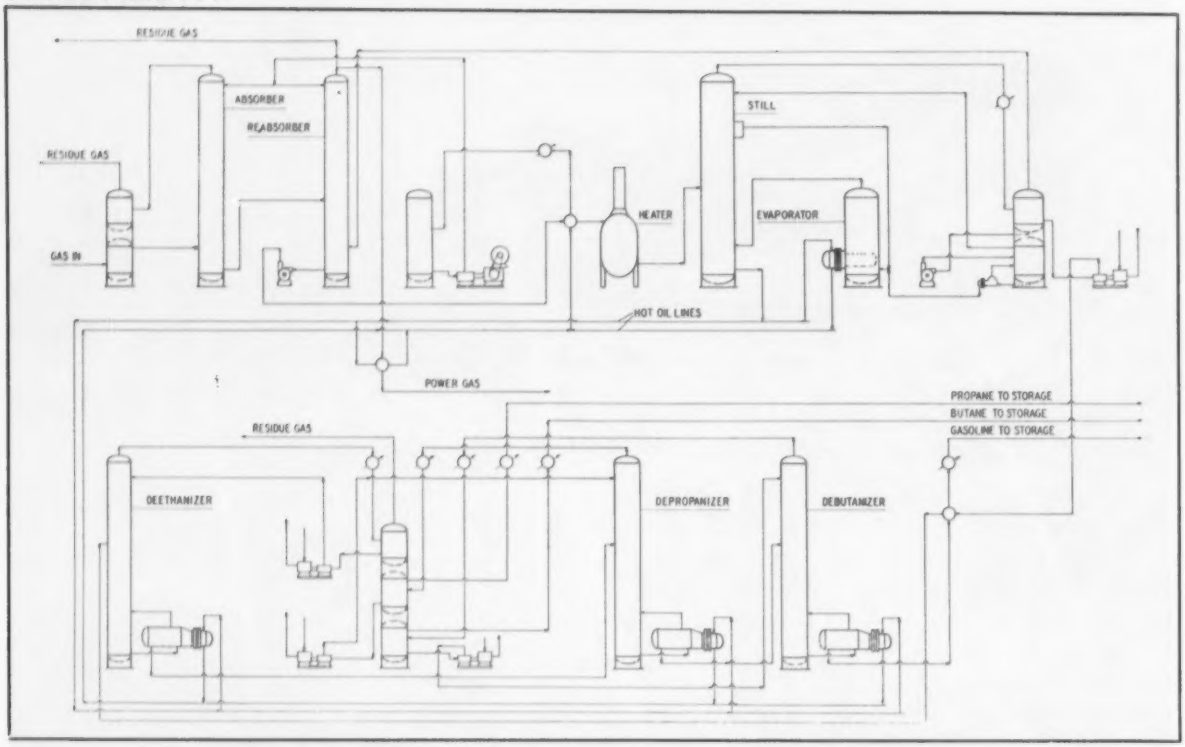

FIGURE 4—Flow scheme: All heat required is furnished by a single oil furnace.

power gas to operate these pumps.

The control instruments are mounted on the skid and near the control points. A central instrument board is not used. The skid unit is now enclosed in a building with the towers projecting through the roof. The vessels are placed quite close together; however, the equipment is so arranged that it is all accessible from one side or the other of the skid. The skids were moved to the job with all possible equipment and piping in place. The towers, of course, were not shipped on the skids. The tower piping, however, was pre-fabricated and lines on the towers were erected with the towers.

The process tanks, such as scrubbers, reflux separators, flash tanks, etc., are stacked two or three high, with tanks requiring elevation for pump suction head, such as reflux tanks, being on top; the bottom tanks being limited to such service as gas scrubbers, oil settlers, etc., where no pump suction problems are involved. The reboilers are placed lengthwise on the skid on either side of the towers as space permits.

Such plants are functionally complete and may be tailor-made for any recovery efficiency justified by the economics of the particular project. They are about as compact, simple, and easy to operate as an efficient plant can be.

It is comparatively easy to determine the cost of the more or less standardized skid units. These units can be purchased by the operator on a fixed price basis. The field costs can be predetermined with fair accuracy, since very little material is required beyond the skid units—principally simple foundations and a little interconnecting piping. Any errors in the estimated field costs constitute only a small percentage of the total cost. The accuracy with which the over-all cost of a project can be predicted is an important factor in the popularity of these plants since the economics of the project is better known in advance.

It is obvious from the description and illustrations that the initial skid unit cost is lower than the conventional type plant and that the salvage value of these skid unit plants is extremely high. This makes the plants much more desirable for the shorter-lived projects than are those of the more conventional type of construction. Not only is the equipment salvagable, but also practically all of the piping and most of the piping labor.

The foregoing discussions on midget gasoline plants originally were presented at the annual NGAA meeting, Fort Worth, Texas, April 11, 1956. ##

Meet the Author

OTHA H. GRIMES is an independent natural-gasoline-plant operator in Tulsa. Engaged in the manufacture of natural gasoline since 1922, he operates plants in Texas and at Weleetka and Pauls Valley, Okla. Also, he is president of Grimes Gasoline Company, Highway Gasoline Company and Apache Gasoline Company. These companies operate plants at Wetumka, Stroud and Ardmore, Okla. Grimes is a former student at Ohio State University.

Nomograph for Combustion Calculations

Here is a quick way to use Orsat data to get combustion values from a nomograph.

L. A. Mekler, Consultant, Petro-Chem Development Company, Inc., and Petro-Chem Process Company, Inc., New York City
E. E. Ungar, New York University, New York City

HERE IS A nomograph to determine from an Orsat flue gas analysis the values needed in combustion calculations. Values are carbon-hydrogen ratio, gross and net calorific value of fuel, theoretical air required, amount of excess air used and sensible and latent heat content in the flue gases. The nomograph is based on the assumption that fuel is completely burned without formation of CO. This is usually the case when liquid and gaseous fuels are burned in boilers and process heaters with an excess air of more than 10 percent over theoretical.

The scale for gross calorific value of fuel is adjusted to take care of the heat of formation of gaseous hydrocarbons which constitute fuel. As shown in Table 1, there is great difference between actual calorific values of gaseous hydrocarbons and values calculated on the basis of hydrogen and carbon content of fuel. The largest difference, 9.1 percent of actual gross heating value, is for methane, the main constituent of natural gas. The difference decreases with the H/C ratio and becomes negative for the olefins. With mixed gases containing appreciable amounts of hydrogen, the difference between actual and calculated gross calorific varies from 8.2 percent for an H/C ratio of 0.39 to 4.8 percent for a ratio of 0.833. The difference is negligible with normal fuel oils with an H/C ratio of 0.10 to 0.15.

The nomograph was derived from equations based on the material balance of the combustion reaction, when burning a mol of fuel C_XH_Y with Mo mols of O_2.

Basic equation of combustion of one mol of fuel C_XH_Y with M_o mols of O_2.

$$C_XH_Y + M_oO_2 + 3.76M_oN_2 = bCO_2 + nH_2O + CO_2 + dN_2 \quad (1)$$

from which, by material balance, the volumetric relationships are

$$O_2 = M_o = \frac{n}{2} + b + c$$

$$N_2 = 3.76M_o = d = 100 - (b + c)$$

$$CO_2 = X = b$$

$$H_2O = \frac{Y}{2} = n$$

also

$$M_o = \frac{100 - (b + c)}{3.76}$$

$$n = 2\,(M_o - b - c) = 2\left[\left(\frac{100 - (b + c)}{3.76}\right) - (b + c)\right]$$

$$= 53.1 - 2.531\,(b + c)$$

$$Y = 106.3 - 5.06\,(b + c)$$

Hydrogen-Carbon ratio, by weight, in C_XH_Y

$$R = \frac{Y}{12X} = \frac{106.3 - 5.063\,(b + c)}{12b}$$

$$= \frac{8.87 - 0.421\,(b + c)}{b} \quad (2)$$

Lbs of fuel per mol of fuel, W_f,

$$W_f = 12X + Y$$

Substituting Y in terms of R and X = b

$$W_f = 12X + 12RX = 12X(1 + R)$$

$$= 12b(1 + R) \quad (3)$$

Air required, lbs/lb of fuel, M_a,

$$M_a = \frac{4.76M_o \times 28.9}{W_f} = \frac{4.76\,[100 - (b + c)] \times 28.9}{3.76 \times 12b\,(1 + R)}$$

$$= \frac{3.05\,[100 - (b + c)]}{b\,(1 + R)} \quad (4)$$

Theoretical O_2 required mols, P_o, per mol of fuel C_XH_Y

$$P_o = X + \frac{Y}{4}$$

Nomograph for Combustion Calculations . . .

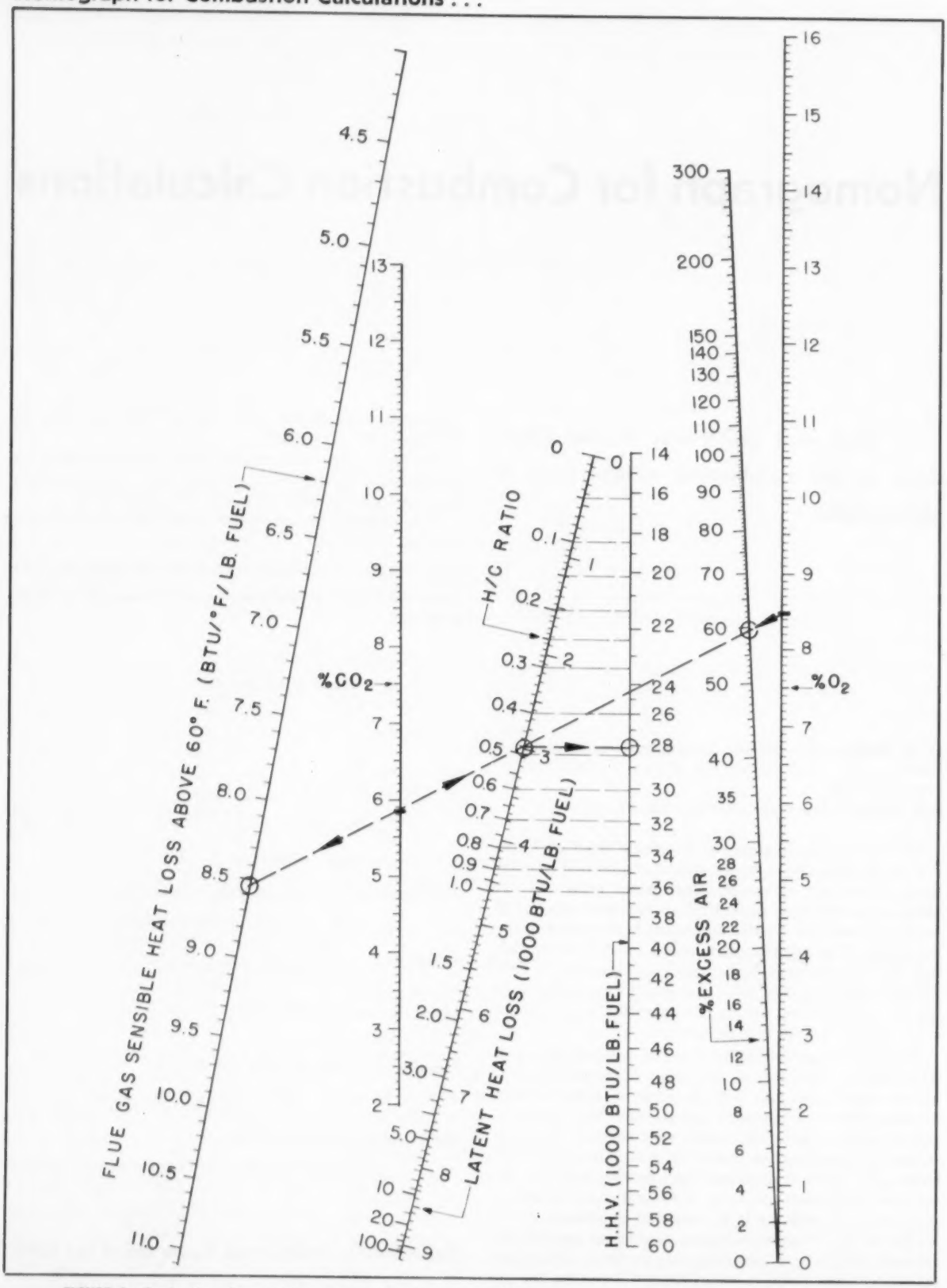

FIGURE 1—Combustion characteristims nomograph—the lower portion has been reproduced at same scale on following page.

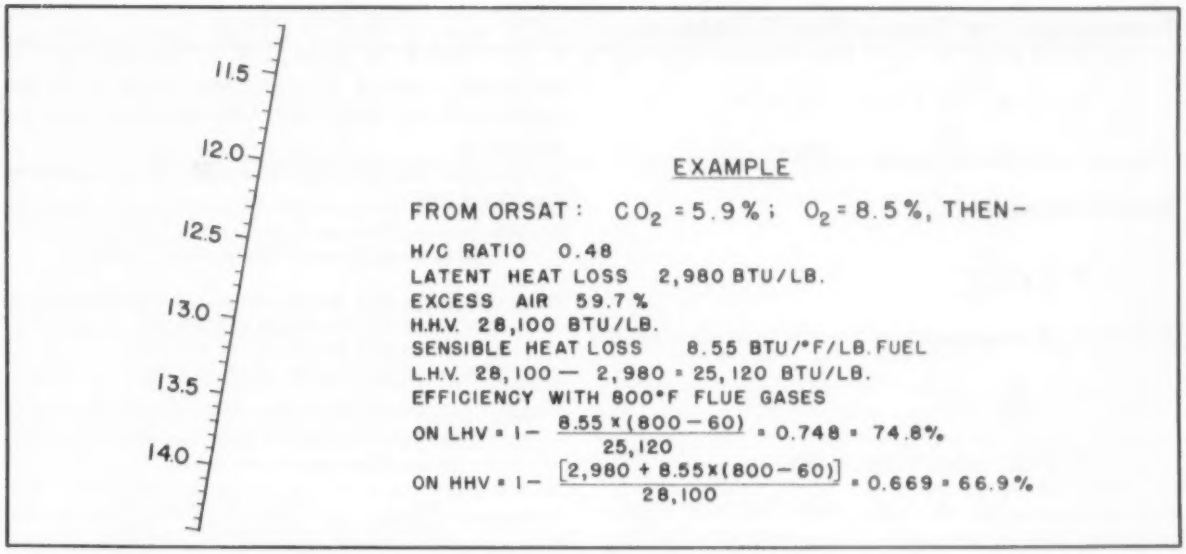
11.5
12.0
12.5
13.0
13.5
14.0
EXAMPLE
FROM ORSAT: CO_2 = 5.9%; O_2 = 8.5%, THEN-
H/C RATIO 0.48
LATENT HEAT LOSS 2,980 BTU/LB.
EXCESS AIR 59.7%
H.H.V. 28,100 BTU/LB.
SENSIBLE HEAT LOSS 8.55 BTU/°F/LB. FUEL
L.H.V. 28,100 — 2,980 = 25,120 BTU/LB.
EFFICIENCY WITH 800°F FLUE GASES
ON LHV = $1 - \frac{8.55 \times (800-60)}{25,120} = 0.748 = 74.8\%$
ON HHV = $1 - \frac{[2,980 + 8.55 \times (800-60)]}{28,100} = 0.669 = 66.9\%$

FIGURE 1a—The lower portion of the nomograph reproduced on preceding page. Scale remains the same for your convenience in the event you wish to clip and piece it together.

Mols of theoretical air required per mol of fuel, P_a,

$$P_a = 4.76\ P_o$$

Lbs of theoretical air required, per lbs of fuel, W_a,

$$W_a = \frac{4.76\left(X + \frac{Y}{4}\right) \times 28.9}{12b\ (1+R)}$$

Substituting b for X and expressing Y in terms of b and R

$$W_a = \frac{28.9 \times 4.76\ (b + 3Rb)}{12b\ (1+R)} = \frac{11.5\ (1+3R)}{1+R} \qquad (5)$$

Excess air used for combustion, A_e percent

$$A_e = \frac{M_a - W_a}{W_a} \times 100 = \left(\frac{M_a}{W_a} - 1\right) 100 = \left[\frac{100 - (b+c)}{3.76\left(b + \frac{106.3 - 5.06\ (b+c)}{4}\right)} - 1\right] \times 100$$

Mekler

Ungar

Meet the Authors

L. A. MEKLER has experience in the petroleum-refining and other thermophysical and thermochemical industries dating back over more than 35 years. Some 20 years of this was with Universal Oil Products Company. A consultant since 1948, his clients have included the Institute of Gas Technology, Armour Research Foundation and Stanford Research Institute. He is author of more than 35 articles on petroleum refining and related fields, and holds more than 80 patents on refining processes.

ERIC E. UNGAR is a doctorial candidate at New York University, where he also serves as an instructor in mechanical engineering. For the past two years, he has been devoting part of his time to research in plasticity and stress analysis in rocket motors. During the same period, he has been associated with L. A. Mekler in work on problems in combustion and refinery equipment. Ungar is a mechanical-engineering graduate from Washington University in St. Louis and holds a master's degree from the University of New Mexico. While studying at both St. Louis and Albuquerque, he was connected with Sandia Corporation. He has been at NYU since leaving Sandia in 1953.

TABLE 1
Comparison of Actual and Calculated Calorific Values

GAS	Wt. % H_2	H/C Ratio	CALORIFIC VALUE, Btu./Lbs.* Actual HHV	Actual LHV	Calculated HHV	Calculated LHV	Difference Btu./Lb.	Difference %(4)
	1	2	3	4	5	6	(6)—(4)	
CH_4	25.0	0.333	23,880	21,520	25,840	23,480	1960	9.1
C_2H_6	20.0	0.250	22,320	20,430	23,490	21,600	1170	5.7
C_3H_8	18.2	0.222	21,660	19,940	22,740	20,920	780	4.8
C_4H_{10}	17.2	0.208	21,260	19,580	22,200	20,550	870	4.4
C_2H_4	14.3	0.167	21,640	20,300	20,815	19,460	(—) 840	(—) 4.1
C_3H_6	14.3	0.167	21,040	19,690	20,815	19,460	(—) 230	(—) 1.2
C H	14.3	0.167	20,840	19,500	20,815	19,460	(—) 40	.....
Mixt. Vol. % H_2 and CH_4								
25–75	28.0	0.389	25,370	22,720	27,250	24,590	1,870	8.2
50–50	33.3	0.500	28,010	24,860	29,760	26,600	1,740	7.3
75–25	45.5	0.833	34,030	29,730	35,460	31,150	1,420	4.8

* To nearest 10 Btu./lb.

$$= \left[\frac{100-(b+c)}{100-(b+4.76c)} - 1\right] \times 100$$

$$= \frac{3.76c}{100-(b+4.76c)} \times 100 \qquad (6a)$$

Similarily excess air is

$$A_e = \frac{c}{X + \frac{Y}{4}}$$

Substituting Y in terms of X = b and R from relationship

$$\frac{Y}{12X} = R$$

$$A_e = \frac{c}{b+3bR} = \frac{c}{b(1+3R)} \qquad (6b)$$

Calculated gross calorific value, HHV Btu/lb of C_XH_Y neglecting heat of formation of the components of the fuel.

$$HHV = \frac{61{,}100Y + (12 \times 14{,}090)X}{12X + Y}$$

Substituting R and X for Y

$$HHV = \frac{61{,}100R + 14{,}090}{R+1} \qquad (7)$$

The HHV values on the nomograph are adjusted for heat of formation.

Latent heat loss in water vapor formed, LHL_m Btu/lb mol of fuel, C_XH_Y.

$$LHL_m = \left(18 \times \frac{Y}{2}\right) h; \; h = 1020 \text{ Btu/lbs of steam at partial press. of 0.15 atmospheres}$$

$$= 9{,}180Y$$

$$LHL, \text{ Btu/lbs of fuel} = \frac{9{,}180Y}{12X + Y}$$

Substituting R and X for Y

$$LHL = \frac{9{,}180}{1 + \frac{1}{R}} \qquad (8)$$

Net heating value of the fuel, LHV, Btu/lb, is the difference between HHV and LHL obtained from the nomograph.

Sensible heat loss, SHL, Btu/lb of fuel /°F stack temperature above 60°F

Sensible heat loss Btu per lb mol of fuel, SHL_m

$$SHL_m = nH_2Oh_1 + bCO_2h_2 + cO_2h_3 + dN_2h_4$$

Where h_1 = ave. sp. heat, Btu/lbs. of $H_2O = 0.470$
h_2 = ave. sp. heat, Btu/lbs. of $CO_2 = 0.235$
h_3 = ave. sp. heat, Btu/lbs. of $O_2 = 0.240$
h_4 = ave. sp. heat, Btu/lbs. of $N_2 = 0.260$

$$SHL_m = [53.1 - 2.53(b+c)] \times 0.47 \times 18 + b \times 0.235 \times 44 + c \times 0.24 \times 32 + [100-(b+c)] \times 0.26 \times 28 = 1178 - 18.35b - 21.0c$$

$$SHL = \frac{SHL_m}{12X+Y} = \frac{1178 - 18.35b - 21.0c}{106.3 + 6.94b - 5.06c} \qquad (9)$$

Table 2 shows a comparison of values as obtained from the nomograph and from detailed calculations for three hydrocarbon gases and a heavy fuel oil. For the fuels used in the examples and the selected excess air and stack temperatures, the agreement is close enough for all practical purposes. A possible exception might be official acceptance tests in border cases where sometimes a deviation of ± 0.5 percentage points may determine whether or not the unit meets the guaranteed efficiency.

The accuracy which can be obtained with the nomograph depends to a great extent on the accuracy of the Orsat analysis. As a general rule the Orsat, if not leaking and with reasonably fresh reagent for the CO_2 cell, can give CO_2 content of flue gases within ± 0.1 percentage points. Analysis of O_2 is much more sensitive to freshness of the solution and manipulation and may be ± 0.5 percentage points off. Since all values in the nomograph are derived directly from O_2 and CO_2 readings, or from H/C ratio determined by these readings, an error in the Orsat analysis will result in errors of all the values.

For an extreme example, if the correct Orsat analysis is 9.7 percent CO_2 and 3.8 percent O_2 and that reported on the test is 9.4 and 3.3 the values obtained from the nomograph will differ as follows from the correct values.

	Correct	Reported
H/C Ratio	0.33	0.38
SHL, Btu/lbs/°F	5.95	6.06
LHL, Btu/lbs	2,300	2,550
HHV, Btu/lbs	23,800	25,500
LHV, Btu/lbs	21,500	22,950
Flue gas losses at 800°F, Btu/lbs	4,400	4,500
Flue gas losses, % LHV	20.4	17.6
Efficiency exclus. of radiat., % LHV	79.6	82.4

The nomograph can be used to check the accuracy of a series of Orsat analyses. If the analyses are correct, each of them will give the same H/C ratio.

TABLE 2
Comparison of Calculated Values with Values from Nomograph

FUELS	CH_4		C_2H_6		H_2+CH_4 50-50 by Vol.		Resid. Fuel Oil C=85.9; H=9.8	
% CO_2,orsat	8.8		8.5		7.2		12.8	
O_2,orsat	5.3		7.5		5.4		5.0	
Stack Temp., °F	800		1000		700		1000	
	Calc.	Nomog.	Calc.	Nomog.	Calc.	Nomog.	Calc.	Nomog.
H/C Ratio	.333	.335	.25	.25	0.5	0.5	.110	.110
Excess Air, percent	30	30	50	50	30	30	30	30
HHV, Btu./lb.	23,880	23,880	22,320	22,300	28,100	28,400	18,270	18,350
LHL	2,360	2,380	1,890	1,840	3,150	3,090	925	930
LHV	21,520	21,420	20,430	20,460	24,950	25,310	17,345	17,420
Theor. Air Lbs./lb. of Fuel	17.27	17.27*	16.12	16.1*	19.2	19.2*	13.7	13.7*
Heat Content of Flue gases, Btu./lb	4,600	4,760?	6,170	6,300	4,450	4,640	4,470	4,660
Thermal Effc'y., Exclusive of Radiation:								
% HHV	70.7	70.4	63.8	63.6	73.0	73.1	69.5	69.6
% LHV	78.8	78.2	69.8	69.3	81.9	81.3	75.2	74.7

* From formula $A_e = \frac{11.5(1+3R)}{1+R}$

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Nomography and Empirical Equations. L. H. Johnson, John Wiley and Sons.
Combustion Calculations for Hydrocarbon Fuels. H. R. Linden and D. F. Othmer. Chemical Engineering, April-May, 1947.

Figure NPSH for Proportioning Pumps

These calculations made now for a new installation may save you costly piping changes and operating delays later.

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NET POSITIVE suction head (NPSH) is important in any pump installation, for with insufficient available NPSH a pump cavitates. For proportioning pumps, cavitation means not merely more expensive maintenance and noisy inefficient operation, but it also means that an all-important factor, accuracy in predicting the pump delivery, is lost to the operator. It is evident, then, that NPSH is a more critical factor where a precise flow is expected.

It is common practice to calculate NPSH conditions for centrifugal turbine or rotary pumps having uniform flow characteristics. Previous articles[1,2,3] explain steady state NPSH calculation very completely. It is rather unusual, however, to have the NPSH calculated for reciprocating power pumps which have non-uniform, pulsating flow.

This article develops a simplified method for calculating NPSH of reciprocating power pumps. Expressions are derived for instantaneous energies of inertia, friction, and velocity. These expressions are simplified, combined, and solved for limiting conditions. Although the expressions are specifically concerned with proportioning pumps, the reasoning may be applied in general to the entire class of crank-driven power pumps.

Terminology—Generally, NPSH and available NPSH are used with the same meaning. Strictly speaking, NPSH has meaning only with reference to a particular point in the system. Without special identification it should denote the internal condition of the pump, representing the residual static pressure inside the pump in excess of the liquid vapor pressure.

To determine NPSH in the pump requires detailed knowledge of the installation conditions and also of the internal design of the pump. The difficulty is that this knowledge usually is divided between the operator and the pump manufacturer. The operator controls and understands the pump installation, while the manufacturer is familiar with the pump characteristics.

A workable solution is reached by taking NPSH at a common point between line outlet and pump inlet. The NPSH at this point is the *available* NPSH or system NPSH; this is the responsibility of the operator. The greatest entrance losses between the pump inlet and the point of lowest pressure inside the pump represent the extreme lower limit allowable for available NPSH. This is the pump NPSH *requirement* and can be specified by the manufacturer in feet of the liquid to be pumped.

NPSH will then be the difference between these two values: i. e., the available NPSH provided by the system minus the pump NPSH requirement or the internal losses within the pump. This difference should be large enough to provide a factor of safety in view of errors in estimating pumping temperatures or taking values for other system variables. Generally speaking, the greater the vapor pressure of the liquid the greater the NPSH allowance should be for safe operation. It is good practice to allow proportioning pumps a more generous and reliable NPSH margin than would be used for a simple transfer operation.

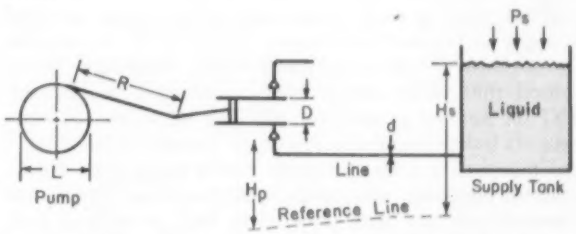

FIGURE 1—This typical proportioning pump installation is expected to deliver an accurate flow. It is important, therefore, that sufficient NPSH be available.

Typical Installation—Figure 1 shows a typical pump installation. The pump is represented schematically as a single-acting simplex power type. This general type of pump when provided with an adjustable crank is commonly called a proportioning pump or a metering pump.

If a high-speed pressure recorder were connected at the common point between the pump inlet and line outlet, a record of instantaneous pressures would be made. One cycle at pressure variations may be represented by Figure 2. The pressure would dip below static value at the start of a suction stroke and rise above static values toward the end of the stroke. The variation from static values can be called dynamic head loss, H_d.

The residual pressure acting on the liquid in excess of vapor pressure is available NPSH and the lowest value it can have; due to changes in temperature, supply level, pressure on the liquid surface, liquid motion during the stroke, and capacity requirement for the associated process; determines the *minimum* available NPSH for a given installation. This value is of most interest to the plant engineer since it must exceed the NPSH requirements for the various pumps considered for the job. The problem for the plant engineer is to provide adequate available minimum NPSH with the most convenient and economical arrangement of pump, supply tank, and piping.

Minimum $(NPSH)_a$—Reciprocating pumps unlike steady state pumps will give different values of *available*

Figure NPSH for Proportioning Pumps . . .

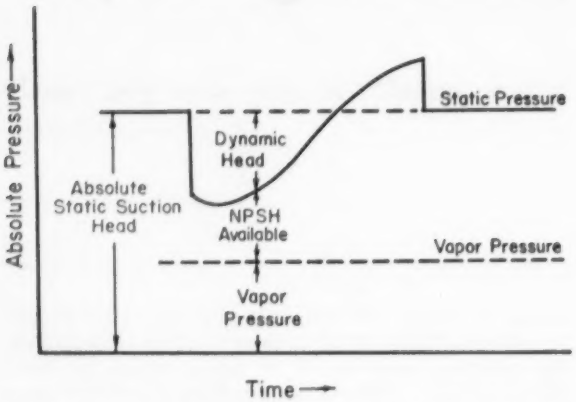

FIGURE 2—Record of instantaneous pressure at the pump inlet would show a great variation in pressure throughout the pumping cycle.

NPSH for a given delivery rate depending on pump design. A large slow-speed pump will give larger available NPSH than a small high-speed pump under identical supply and capacity conditions. While NPSH *requirement* is obviously a function of pump design it should be recognized that pump design has an influence on available NPSH and no general formula can be arrived at completely independent of pump design factors. In the absence of pump data a good estimate can be made from the required pumping capacity for typical designs. Where such assumptions are made they apply only to typical, well-designed proportioning pumps and should not be applied to the entire class of power pumps.

The basic formula for available NPSH is:

$$(NPSH)_a = H_a - H_p + \frac{2.31}{G}(P_a - P_v) - H_d \qquad (1)$$

Usually P_a is the pressure exerted by the atmosphere and should take into account sea level elevation and barometric changes due to weather. For liquefied gases pumped from closed storage, $P_a = P_v$. Then $(NPSH)_a = H_a - H_p - H_d$, if the temperature remains constant throughout the system.

Finding minimum $(NPSH)_a$ for any system will require taking P_a at minimum, H_a at minimum, P_v at maximum pumping temperature, and H_d at the particular combination of conditions giving the greatest instantaneous value during the suction stroke.

In Figure 3 the inlet pressure trace is analyzed in terms of components of H_d. H_d is the instantaneous sum of inertia, H_i; friction, H_f; and velocity head, H_v. The sum of these three individual components can produce a peak value of H_d greater than any single component at maximum, depending on their rise and fall with respect to each other. The flow transient, H_d, may then be related to the liquid flow properties and the associated crank motion.

Inertia Head—Inertia is determined by considering that, in accelerating a unit mass through a distance N, work is done, *N* times *a*, equivalent to the potential energy, H times g. For an entire section of pipe where the acceleration remains the same due to uniform cross sectional area, the instantaneous head loss due to inertia will be:

$$H_i = \frac{aN}{g} \qquad (2)$$

This inertia head loss represents a change from the condition of rest or steady state flow and applies for the length N down the centerline of a uniform pipe regardless of whether it is horizontal or vertical. H_i acquires the sign associated with *a*. Increasing velocity along the line of flow produces a loss in pressure. Decreasing velocity, or deceleration in the direction of flow, produces a negative head loss or rise in pressure for the section of line. This leads to the conclusion that H_d will be at its maximum magnitude at or near the start of the stroke.

In this derivation of H_i the assumption is made that the piping system is completely filled with liquid which does not appreciably change in volume with small changes in pressure so that the mass rate of flow maintains continuity, being equal through any section in the system. This is true as long as there is no cavitation. To assume that cavitation does take place would lead to an analysis of operation for an unsatisfactory system and be of no benefit. Since H_d cannot exceed the available static driving forces, computed values of H_d in excess of these forces will require changes to reduce losses or increase the static driving force.

By continuity, the total value of H_i will be affected by the depth of liquid in the tank; however, the ratio of a/g in any practical supply tank is extremely small to the point of vanishing. N is usually taken for the line only where liquid acceleration and velocity are appreciable.

Inertia is an extremely important factor in determining dynamic losses for a reciprocating pump, and, when flow is turbulent, it can be shown that it is the only factor needed to determine H_d at maximum for typical proportioning pumps.

Friction and Velocity Heads—Friction loss and velocity head are related to the internal behavior of the liquid. All flow as it starts from rest is streamline and may become turbulent if sufficient kinetic energy is imparted to it so that the rather weak cohesive forces in the liquid are broken down.

For streamline flow the velocity head, or mean kinetic energy, in any cross-section of the pipe is given by:

$$H_v = \frac{u^2}{g} \qquad (3)$$

Friction loss during streamline flow is given by Poi-

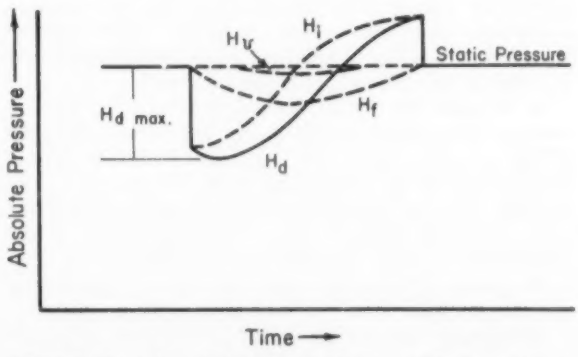

FIGURE 3—Total dynamic head loss is the sum of the losses due to friction, inertia and velocity.

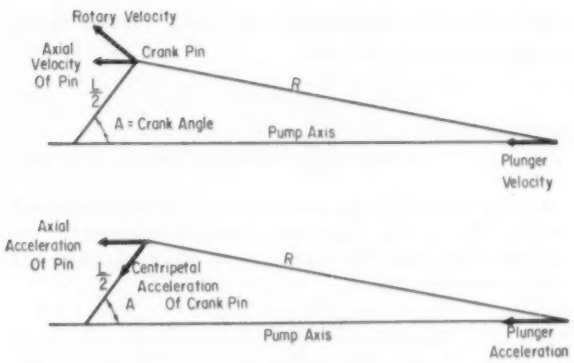

FIGURE 4—Liquid motion may be related to the motion of the crank pin for a given reciprocating pump.

seuille's law. In convenient units this can be written:

$$H_r = \frac{NuC}{646d^2G} \quad (4)$$

The effect of pipe fittings and internal roughness is negligible for streamline flow.

For turbulent flow the velocity head approaches as an ideal limit, $u^2/2g$ where all the liquid in the cross section is moving at the same velocity. A more practical value can be taken as:

$$H_v = \frac{u^2}{60} \quad (5)$$

Friction losses for turbulent flow of any fluid are usually determined by Fanning's formula which can be written in its simplest form as:

$$H_f = \frac{fNu^2}{1.34d} \quad (6)$$

The Fanning friction factor, f, is a function of pipe roughness and Reynolds number. Values of f vary a comparatatively small amount with turbulent flow and plots of f versus Reynolds number do not show values for use in this region in excess of 0.014. A value for f in Equation (6) of 0.02 could be taken as a rather extreme estimating value for small corroded pipe.

Calculating turbulent flow is troublesome and inaccurate. Values of f for the turbulent region are accurate to no better than plus or minus 5 per cent. Fortunately it is not necessary to determine friction loss when there is turbulent flow for typical proportioning pump installations.

The Reynolds number, R_e, is used to determine whether flow is streamline or turbulent. An R_e below 2100 is streamline and above this number may be turbulent. The assumption of turbulent flow results in a greater value for H_f.

The Reynolds number can be found from convenient units by the following expression:

$$R_e = 7740\,\frac{duG}{C} \quad (7)$$

From this it can be seen that flow will be streamline if duG/C is 0.27 or less; and if over 0.27, friction loss will be greater if turbulent flow is assumed.

Flow Related to Crank Rotation—In order to find H_i, H_f, and H_v it is necessaary to find the liquid acceleration, a, and velocity, u, during the suction stroke and to relate them as component vectors in producing the maximum dynamic head loss, H_d max.

Liquid is related to plunger motion by continuity, and the plunger motion is related to the crank rotation through a connecting rod or eccentric link. For the liquid:

$$u = \text{plunger velocity} \times (D/d)^2 \quad (8)$$

$$a = \text{plunger acceleration} \times (D/d)^2 \quad (9)$$

The tilt of the connecting rod leads to a distorted relation between the rotary motion of the crank pin and the motion of the plunger. The rotary motion of the crank pin produces a simple harmonic axial motion of the pin. The plunger motion does not exactly correspond to this axial motion because of the changing axial distance between the crank pin and wrist pin. The main effect is a distortion of the time scale when actual plunger motion is compared to the axial harmonic motion of the crank pin.

In Figure 4 the axial velocity of the crank is equal to $\frac{Ln}{229}\sin A$, the axial acceleration is $\frac{Ln^2}{2185}\cos A$, and their relation to actual instantaneous plunger motion where R = 2.5L is shown in Figure 5. The plunger velocity at

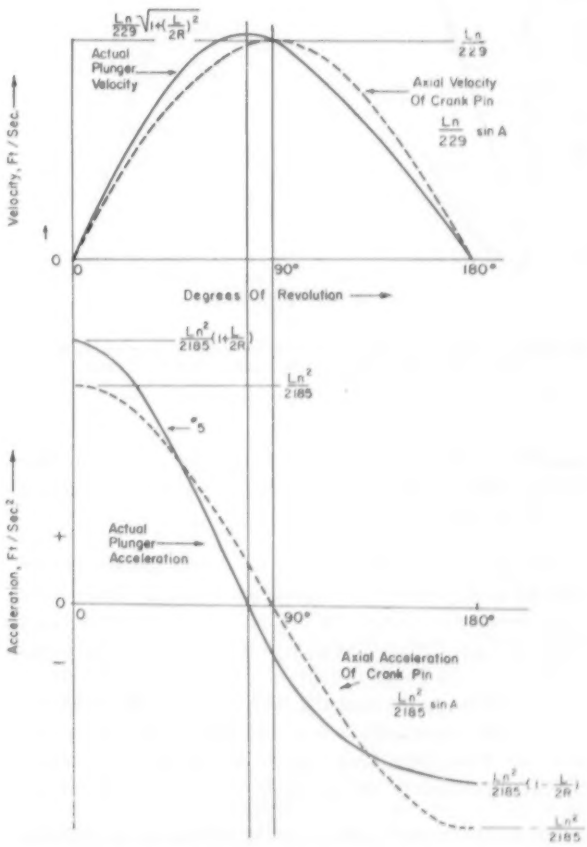

FIGURE 5—Relation of liquid motion to crank pin motion is represented by these curves.

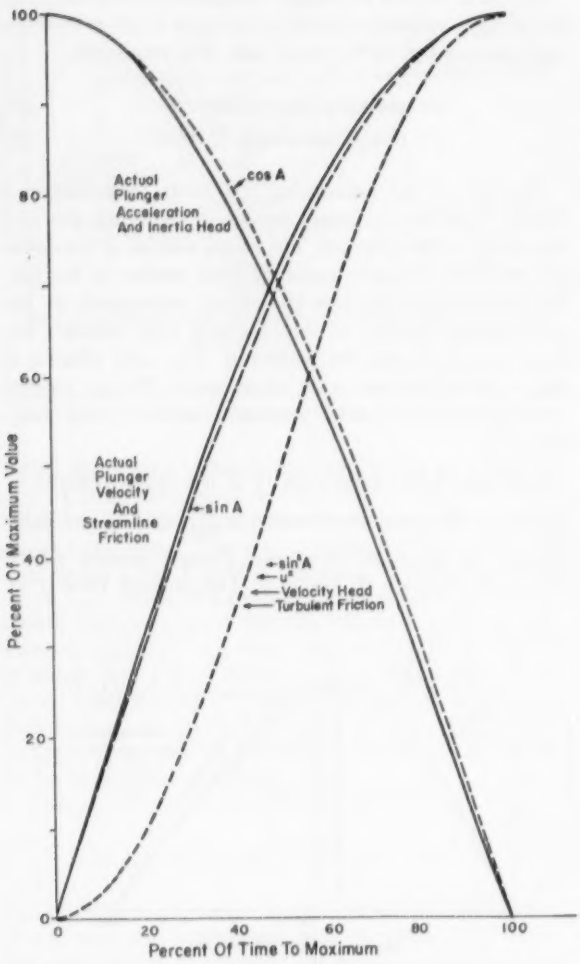

FIGURE 6—Simplified expressions may be obtained by plotting energy terms versus time required to reach a maximum value.

maximum slightly exceeds (about 2 percent) the harmonic value. The negligible correction factor being $\sqrt{1 + (L/2R)^2}$

The plunger acceleration at maximum greatly exceed (20 percent greater) the harmonic axial acceleration of the crank, the correction factor for acceleration being $(1 + L/2R)$. Proportioning pumps normally have values for R between 2 and 3 times the value for L, the maximum stroke length, and this may vary by about 10 per cent in the corrected value for maximum plunger acceleration. This correction should be applied in making NPSH calculations, or the typical correction of 1.2 applied, when L/2R is not known.

Maximum liquid velocity and acceleration for the suction stroke can be found from Equations 8 and 9 using correction values for relating the crank motion to the plunger motion, as follows:

$$u_{max} = \frac{Ln}{229}(D/d)^2 \qquad (10)$$

$$a_{max} = \frac{Ln^2}{2185}(D/d)^2\,(1 + L/2R) \qquad (11)$$

Inertia head, H_i, can now be found from Equations 2 and 11. The simplest expression for H_i is obtained by also applying Equation 10, since u max. is common to the other components of H_d.

$$H_{i\,max} = \frac{N\,(u\,max)\,n}{307}\left(1 + \frac{L}{2R}\right) \qquad (12)$$

To simplify further the expressions for instantaneous energy losses, the percentage of maximum rise or fall of each is plotted against the percent of the total time required for the change. This plot is shown in Figure 6. A striking agreement is noticed between liquid velocity and acceleration and the harmonic values of Sin A and Cos A, respectively. This agreement is not apparent in Figure 5 due to the shift in the time scale and the amplitude shift in the acceleration curve.

If the values for plunger motion taken from handbook tables are given for every 10 degrees and the peak is reached in approximately 80 degrees, each 10-degre angular increment corresponds to about 12½ per cent of the total 80 degrees. For the harmonic function requiring 90 degrees to go from zero to peak value, 12½ percent is slightly more than 11 degrees. The change in harmonic values over each 11-degree angular increment is very nearly the same as the change in velocity and acceleration when expressed as percent of maximum value. A plot of Sin^2 A is also shown in Figure 6 to indicate the change in the factors of turbulent friction and velocity head which vary as the velocity squared. It can be seen that streamline friction loss builds up rapidly to a fairly high percentage of its total rise, about 30 percent, in the same time that turbulent friction would be less than 10 percent of maximum. Inertia would have declined only 5 percent from its initial peak value during this time.

The peak value of H_d can occur only when friction, inertia, and velocity head are combined. By the time the plunger passes its midstroke position, inertia loss has passed through zero and becomes opposed to friction and velocity head. During this first half of the suction stroke they will combine to form a peak if friction and velocity head can increase faster than inertia decreases. This will be a function of their separate maximum values and their comparative rates of change as shown on Figure 6.

Maximum Dynamic Losses—For streamline flow any instantaneous value of H_d is given by:

$$H_d = H_{i\,max} \cos A + H_{f\,max} \sin A + H_{v\,max} \sin^2 A \qquad (13)$$

For turbulent flow the instantaneous value is given by:

$$H_d = H_{i\,max} \cos A + (H_{f\,max} + H_{v\,max}) \sin^2 A \qquad (14)$$

There does not appear to be a simple solution of Equation 13 for maximum value but it can be readily shown that it cannot exceed and is closely approximated by the

following expression since values of H_v max. are practically negligible:

$$H_d max = \sqrt{H_i max^2 + (H_f max + H_v max)^2} \quad (15)$$

For equation 14, assuming that flow becomes turbulent practically from the start of the stroke:

$$H_d max = H_f + H_v max + \frac{(H_i max)^2}{4 (H_f max + H_v max)} \quad (16)$$

$$\text{when } (H_f max + H_v max) > \frac{H_i max}{2}$$

For values of friction loss plus velocity head at maximum equal to or less than one-half inertia at maximum, the value of H_d max cannot be greater than H_i max. This means that the slow rise of turbulent friction and velocity head tends to prevent a combined loss greater than inertia at maximum. Unless together they are more than half as large as inertia, their rise does not offset the decline in inertia from the start of the stroke.

To determine if this can happen it can be assumed that H_v and tank outlet losses, pipe fittings, etc., represent 20 percent of the line friction loss for a typical supply system. Taking $(1 + L/2R)$ at the typical value of 1.2 and f, the friction factor, at an improbably high value of 0.02, Equations 6 and 12 can be compared and the final conclusion reached that inertia will exceed friction and velocity head by more than a factor of 2 in all cases where the expression LD^2/d^3 is less than 25. If the stroke length, plunger size, and inlet size of typical proportioning pumps are taken, the largest value found is approximately 20. Usually, much smaller values are found. For more normal values of f, 0.01 or less, there would be no doubt that, with turbulent flow friction, losses do not need to be considered. Reduction of the supply line below inlet size would invalidate this conclusion but this is universally recognized as poor installation practice.

Since streamline flow is known to occur for Reynolds number over 2100, Equation 16 can be considered in doubt since it pre-supposes turbulent flow during practically the entire stroke.

The more rapid initial rise of streamline flow to maximum always produces a resultant larger than inertia alone, since, for streamline flow, inertia and friction are vectors at right angles. While the resultant, H_d max, is always greater in theory than H_i max, it is not appreciably greater as a practical consideration unless H_f max is at least 25 percent of H_i max. Neglecting H_v, H_d will be about 3 percent greater than H_i when H_f is one-quarter of H_i. This is a negligible correction to make in this type of calculation since viscosity, vapor pressure, and other data are known to no greater degree of precision.

Equations 4 and 12 indicate that for streamline friction loss at maximum to exceed one-fourth maximum inertia loss the expression d (u max) $G/_C$ would have to be less than 0.14. This is based on $LD^2/d^3 = 20$, an upper limit for proportioning pumps. The value 0.14 corresponds to a Reynolds number of 1075, well below the possible transition region. Where d (u max) G/C is greater than 0.14, assuming that the flow is streamline does not give an appreciable increase of H_d max. over H_i max. Thus, the value of H_d max. is not appreciably affected by friction losses, whether streamline or turbulent, unless the value of d (u max) G/C is greater than 0.14.

In most cases there would be little error if velocity head were neglected completely. However, it becomes a fairly significant factor with streamline flow and H_d max. occurs nearer the midstroke position.

To be sure that in all cases H_v max. will be less than 5 percent H_f max, the value of N/d must be greater than 400 d (u max) G/C. Since the largest value of interest for this latter expression is 0.14, N/d would have to exceed 56. This value is impossibly large and therefore H_v cannot be eliminated entirely. For a short supply line and a liquid, not too viscous, H_v can have a significant effect on H_d.

While the general formulas given apply to any simplex or duplex single-acting or double-acting power pump, the final conclusion and short cuts apply specifically to normal well-designed proportioning pumps, in capacities up to about 20 gpm per single-acting cylinder. Large power pumps may have values for LD^2/d^3 or $(1 + L/2R)$ outside the limits common for small power pumps and friction loss for values of d (u max) G/C greater than 0.14 might have to be considered. The dimensionless ratios N/d, LD^2/d^3, L/2R, and d (u max) G/C give a remarkably simple key to a given pipe-pump-flow system in predicting over-all behavior.

Remember Three Steps—The following summary gives the necessary calculations for the determination of NPSH for proportioning pumps when pump dimensions are given:

(1) Find u max from $\frac{Ln}{229}(D/d)^2$

(2) Find $\frac{d\ (u\ max)\ G}{C}$

(3A) If $\frac{d\ (u\ max)\ G}{C}$ greater than 0.14

$$H_d max = H_i max$$

(3B) If $\frac{d\ (u\ max)\ G}{C}$ equal to or less than 0.14

$$H_d max = \sqrt{H_i max^2 + (H_f max + H_v max)^2}$$

$$\text{where } H_i max = \frac{Nn\ (u\ max)}{307}(1 + L/2R)$$

$$H_f max = \frac{NC\ (u\ max)}{646\ G\ d^2}$$

$$H_v max = \frac{u\ max^2}{32.2}$$

When the pump capacities in gpm are given, the steps are as follows:

(1) Find u max from $1.4\ \frac{GPM}{d^2}$

(2) Same as before.

(3) Same as before.

$$\text{Taking } H_i max = \frac{N\ (u\ max)}{6.4}$$

(When pump operated at 58 rpm and $1 + L/2R = 1.2$)

To demonstrate the usefulness of this method, several example problems are worked in the accompanying boxes.

Multiplex Pumps and Overlapping Flow—There are some proportioning pumps which are designed so the flow velocity never reaches zero during the pumping cycle as it does for single-acting simplex pumps. A triplex single acting pump having cranks set 120 degrees apart is an example of the class of multiplex power pumps having a continuous but fluctuating flow. This is an interesting example between intermittent and steady state pumps.

Figure NPSH for Proportioning Pumps . . .

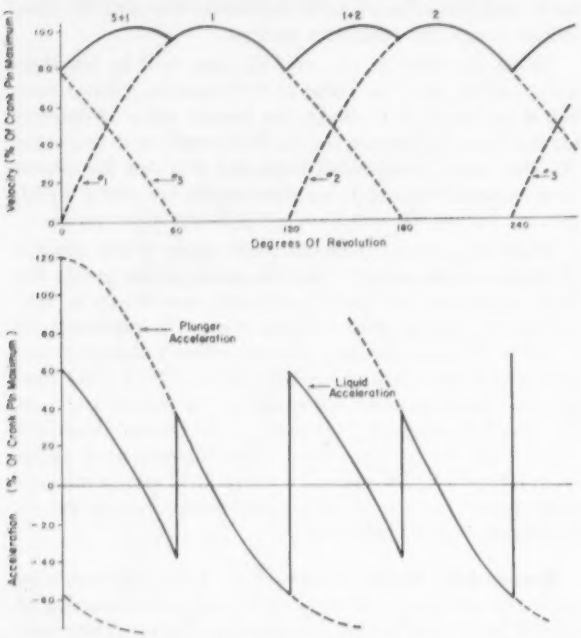

FIGURE 7—Since plunger motions overlap for a triplex single-acting pump, fluid velocity never reaches zero.

Plunger and liquid motions are shown in Figure 7.

Overlapping flow from each cylinder produces pulsations which are interrupted abruptly as a following crank begins to retract its plunger or piston. Total flow varies only between 80 percent and approximate harmonic maximum. This does have a significant inertia effect as can be seen from the sawtooth acceleration curve. Acceleration reaches a peak of about 60 percent of harmonic values or about one-half the values for a simplex or duplex pump at maximum. While these will produce inertia loss peaks less than a simplex or duplex pump; these peaks occur, not while the velocity and friction losses are zero, but when they are at nearly maximum value.

For turbulent flow the condition which should be most likely to give H_d max. would be the start of the composite curve when H_i is 60 percent of harmonic maximum and H_f and H_v at 60 percent of the value based on maximum for a single cylinder. For a small line or a large number of fittings in the line to increase turbulent friction losses it might be necessary to check the value of H_d when H_i is 40 percent harmonic maximum and friction loss and velocity head 90 percent of maximum. For streamline flow this latter condition is more likely to produce H_d max. although for either type of flow two combinations of the same components can be checked almost as quickly as one.

Thus, for a triplex pump supplied by a single line with equal sized single acting cylinders, H_d max. is given by:

Turbulent

$$H_d \text{ max.} = 0.6\,\frac{N\,(u\text{ max})\,n}{307} + .6\,\frac{f\,N\,(u\text{ max})^2}{1.34d} + .6\,\frac{u\text{ max}^2}{60}$$

or,

$$H_d \text{ max.} = 0.4\,\frac{N\,(u\text{ max})\,n}{307} + .9\,\frac{f\,N\,(u\text{ max})^2}{1.34d} + .9\,\frac{u\text{ max}^2}{60}$$

whichever is greater.

Streamline

$$H_d \text{ max.} = 0.6\,\frac{N\,(u\text{ max})\,n}{307} + .78\,\frac{N\,(u\text{ max})\,C}{646d^2G} + .6\,\frac{u\text{ max}^2}{32.2}$$

or,

$$H_d \text{ max.} = 0.4\,\frac{N\,(u\text{ max})\,n}{307} + .95\,\frac{N\,(u\text{ max})\,C}{646d^2G} + .9\,\frac{u\text{ max}^2}{32.2}$$

whichever is greater.

For turbulent friction, take f at u max and include fittings in the value taken for N. For turbulent velocity head, include tank to line entrance losses.

To assist in applying these NPSH calculations to any pump, use these equations:

$$\text{Single acting pumps: GPM} = \left(\frac{D^2Ln}{294}\right)(Ev)\ (\text{No. cyl.})$$

$$\text{Double acting pumps: GPM} = \left(\frac{Ln}{294}\right)(2D^2 - P^2)(Ev)\ (\text{No. cyl.})$$

Where there is no surge chamber or column the maximum instantaneous liquid velocity will be related to pump delivery by the following:

$$\text{Any single acting pump: u max} = \frac{1.4\,\text{GPM}}{d^2\,(\text{No. cyl.})}\ \text{approx.}$$

$$\text{Double acting, simplex: u max} = \frac{\text{GPM}}{1.25d^2}\ \text{approx. (larger stroke)}$$

$$\text{Double acting, duplex: u max} = \frac{\text{GPM}}{2.86d^2}\ \text{approx.}$$

For any pump with a good surge chamber or column giving steady flow,

$$u\text{ max} = \frac{\text{GPM}}{2.44d^2Ev}$$

when the volumetric efficiency is 92 percent,

$$u\text{ max} = \frac{\text{GPM}}{2.24d^2}$$

These expressions for u max. permit the determination of H_d at maximum for practically any crank driven pump.

Effect of Pipe Size—These calculations show that pipe size has a very large influence on NPSH both in reducing inertia losses and friction losses. As a general rule, for

Meet the Author

JOHN HEFLER, a chemistry graduate from Cornell University, became interested in hydraulics and tidal flows and specialized in these fields during six years with the U. S. Engineers. After graduate studies at the University of Rhode Island, he joined Proportioneers in 1943 and was made a research engineer three years later. He now is development supervisor with Proportioneers.

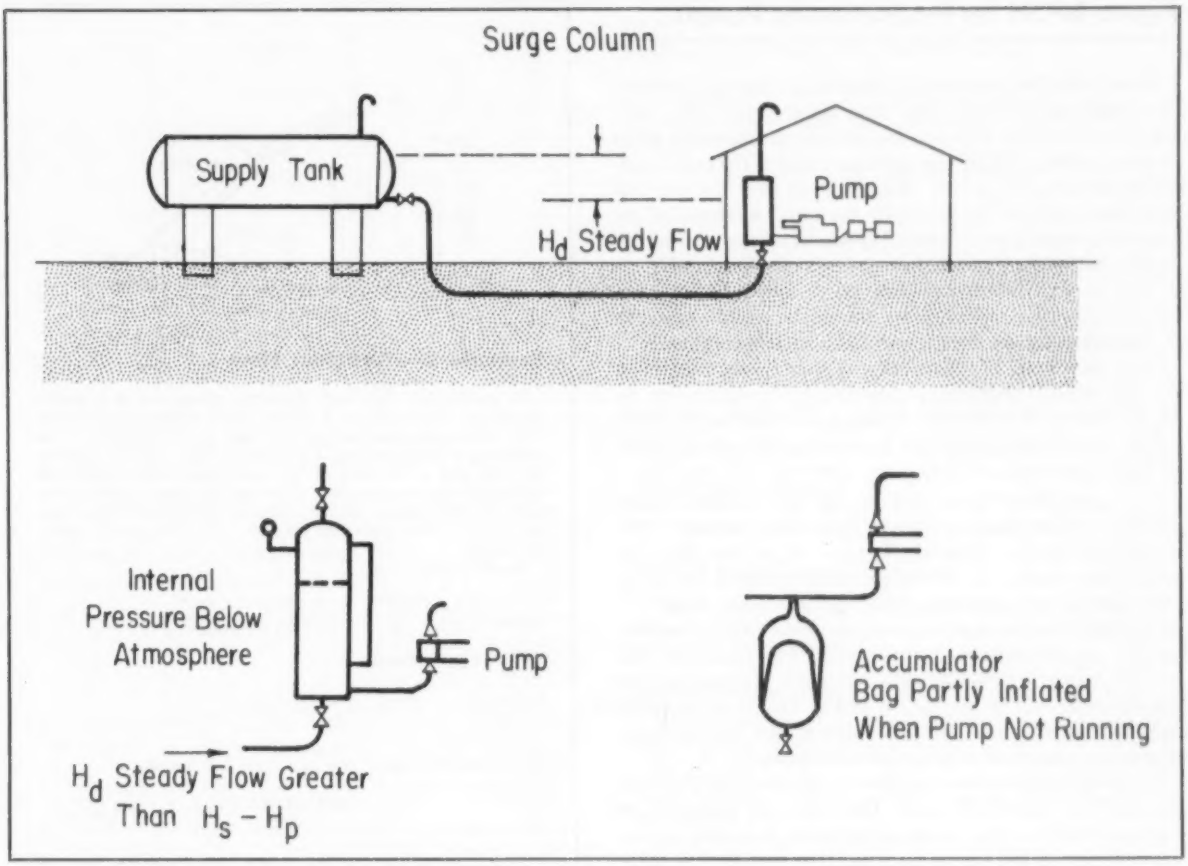

FIGURE 8—Available NPSH for a pumping installation may be increased by several means.

more than ten feet of supply line piping should be increased by at least one size over inlet connection.

While $\frac{d\,(u\,max)\,G}{C}$ can be found directly as a function of capacity in GPM by the expression $\frac{1.4\,(GPM)\,G}{Cd}$ it is more convenient to make the extra step and find maximum velocity.

For good operation, suction velocities should not exceed 2 to 3 feet per second and for viscous liquids even lower velocities are desirable. The value du G/C can be estimated mentally and a rough estimate made of the comparative importance of friction and inertia for a given installation. Changing values for d while changing inertia has an even larger effect on friction losses when flow is streamline.

If a pump has flooded suction, ten feet of line, and negligible vapor pressure, inertia, and velocity head; the total driving force available is 14.7 pounds per square inch absolute. If the velocity were 3 feet per second and the line were 1 inch IPS, the maximum allowable viscosity would be 804 cp. However, for a one-half inch pipe (0.622 inch inside diameter), a viscosity of 282 cp would give H_f max. equivalent to 14.7 pounds per square inch. From these considerations, it can be seen that smaller lines at the same velocities offer greater resistance to flow. This explains why it is easier to handle viscous liquids at fairly high capacities rather than at rates of a few gallons an hour. It is a common error to underestimate required line size for intermittent flow.

How to Increase NPSH—The ability of the pump itself to handle high viscosity liquids is a function of valve size. If, for a given capacity, a very slow speed is taken, the pump cylinder and the associated valve size will be larger. Not only will inertia be less with reduction in n and u max. for the larger inlet pipe size but the value of friction losses will be very greatly reduced. Whenever possible, pump manufacturers provide slower drive speeds for viscous liquids. The fact that this may lead to higher first cost of equipment makes it of interest to consider ways of increasing NPSH in addition to changing line size and reducing lengths.

Frequently, for convenience in materials handling or to reduce a safety hazard, the supply tank is located at a distance from the pump. If the line is steam traced or is underground or is of special alloy it may be desirable to try to use such an existing line, even if undersize, and increase NPSH by other means.

Several methods are shown in Figure 8 for increasing NPSH when N and d cannot be changed without considerable expense. The surge column or chamber coupled to a pump has the advantage of averaging out the pulsating flow so that it is $1/\pi$ times the original u max.

Inertia is practically negligible since it only affects the liquid in the short line between the pump inlet and the

column. The long run of pipe would have streamline friction reduced to about one-third its original value and for turbulent flow it would be reduced to one-tenth of its original value. NPSH calculations for this type of installation would show a vast improvement over the original condition and can be found by the usual methods of determining steady state losses. H_d would be the sum of the steady state values of friction and velocity head only.

The surge column can also be designed to act as a check calibration column, an extremely useful device in maintaining pumps in efficient and accurate condition.

The limitation of this device is that there must be a flooded supply system H_s min above H_p equivalent to H_d for steady flow. It can, however, be used on liquefied gas or closed storage systems by venting the column back to the supply tank.

For cases where there is a suction lift, a closed surge chamber rather than an open column must be used. This is also true if the value of H_s min—H_p is less than the steady state losses, H_d. When properly operated the surge tank can greatly improve system performance. Care has to be taken to prevent internal air leaks and to hold a proper equilibrium level by having the chamber full enough when it is sealed off. The drop in pressure for this chamber will be equivalent to H_d. This requires more care by the operator than a column but has a wider scope for a variety of supply tank conditions.

To simplify operation somewhat, an inverted bag type accumulator might be used. This must be arranged so that the static suction pressure corresponds to only a partial inflation of the elastic bag and that the drop in pressure due to dynamic losses does not cause the remaining gas in the bag to expand completely to full volume. This can be done if the gas bag volume is known and gas is released to allow a measured amount of liquid to prefill the chamber; i.e., practically the reverse of usual accumulator practice.

SYMBOLS USED

a	liquid acceleration, feet per second per second
C	liquid viscosity, centipoise
d	line inside diameter, inches
D	plunger diameter, inches
E_v	pump volumetric efficiency, decimal value
f	fanning friction factor
G	specific gravity, water at 62.4 pounds per cubic foot = 1
GPM	maximum pumping capacity per cylinder, gallons per minute
H	head, feet of liquid pumped
H_d	total dynamic head loss, feet
H_f	friction head, feet
H_i	inertia head, feet
H_p	pump inlet height above reference, feet
H_s	liquid level above reference, feet
H_v	velocity head, feet
L	maximum pump stroke, inches
n	crank shaft revolutions per minute
N	length of supply line, feet
P_s	pressure on liquid surface, psia
P_v	liquid vapor pressure, psia
R	length of pump connecting rod, inches
u	liquid velocity, feet per second

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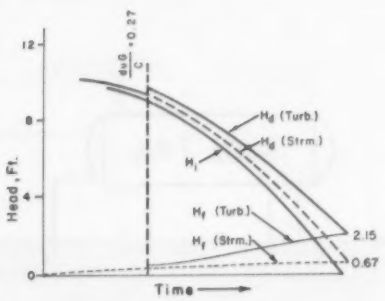


Example 1—Turbulent Flow

A pump with 1¼ inch diameter plunger and 3 inches maximum stroke length is driven at 58 strokes per minute. The inlet port size is ½ inch and it is assumed to be pumping a light fuel oil. The fuel oil has a specific gravity of 0.85 and a viscosity of 3.1 centipoise. Flow would be streamline for at least one third of the time between the start of the stroke and maximum velocity. There is a chance that flow does not become turbulent at all during the stroke.

In this case,

$$u\ max = \frac{Ln}{229}\left(\frac{(D)^2}{d}\right) = \frac{(3)(58)}{(229)}\ \frac{(1.25)^2}{(0.662)} =$$

3.07 feet per second

$$\frac{d(u\ max)G}{C} = \frac{(0.622)(3.07)(0.85)}{3.1} = 0.524$$

$$H_d\ max = H_i\ max = \frac{N(u\ max)n}{307}(1 + L/2R) =$$

$$\frac{(15)(3.07)(58)}{(307)}(1.2) = 10.4\ feet$$

In the accompanying figure, the individual components of dynamic loss are shown between the start of the stroke and maximum velocity. If flow at maximum is assumed to be streamline H_f max will be 0.67 foot and H_v max, 0.29 foot.

If flow is assumed to be turbulent at maximum, H_f max. will be 2.15 feet and H_v max. 0.16 foot. It is assumed that flow becomes turbulent for values of du max G/C above 0.27. The small friction component for the streamline portion of the cycle does increase very slightly faster than inertia declines at the very start of the stroke but its effect is very minute and by the time turbulent flow can occur the increase in friction loss is much too small to produce a peak value greater than inertia alone at maximum. If turbulent flow is assumed from the start of the stroke its early values would be lower than for streamline flow since it approaches maximum by the slower starting sine squared curve. So would velocity head.

These comparative magnitudes for the three factors which combine to produce H_d are typical and more strongly turbulent flow would show a lesser proportion of friction loss in the total effect, H_d.

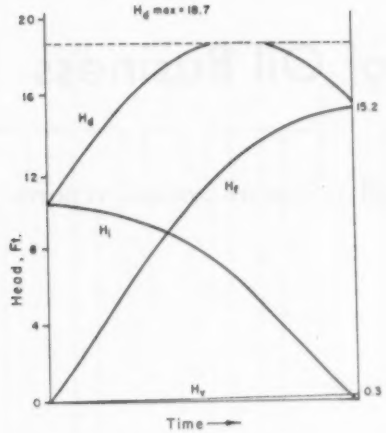
Example 2—Streamline Flow

If the same installation is taken as handling a liquid of 70 cp viscosity, flow will be definitely streamline since:

$$\frac{d(u\ max)G}{C} = \frac{(0.622)(3.07)(0.85)}{(70)} = 0.0232$$

$Re = 179.$

In the accompanying figure the relative magnitude of inertia friction and velocity head are shown. It can be seen that the friction component is now of greater significance than inertia. An entirely different curve for H_d results, producing a peak value considerably greater than either component alone at maximum.



$$H_f \text{ max} = \frac{N(\text{u max})C}{646\, d^2 G} = \frac{(15)(3.07)(70)}{(646)(0.622)^2(0.85)} = 15.2 \text{ feet}$$

H_v max = 0.29 feet as in Example 1

H_i max = 10.4 feet as in Example 1

$$H_d \text{ max} = \sqrt{H_i \text{ max}^2 + (H_f \text{ max} + H_v \text{ max})^2}$$
$$= \sqrt{(10.4)^2 + (15.5)^2} = \sqrt{108 + 240} = \sqrt{348}$$
$$= 18.7 \text{ feet}$$

This predicted value for the peak of H_d is shown in the figure. If this installation had a flooded suction of two feet, it can be seen that the inlet pressure momentarily would be more than 16 feet of liquid below atmospheric or 6 psi below atmospheric.

Even if the liquid vapor pressure is negligible there is always the possibility of internal leakage of air at pipe joints, fittings or through the pump stuffing box. This has happened where the pump obviously had a "flooded suction" and the liquid was considered to be "not very viscous." Air bubbles are one of the most common and annoying reasons for loss of accuracy in a proportioning pump. If there is a steady seepage of air into the line or past the plunger packing the pump delivery will consistently remain below its predicted value and in some cases the pump may become completely airbound and fail to deliver liquid altogether.

It is apparent that many installations of only moderately viscous liquids are apt to be troublesome. This is not due to the limitations of the pump itself since plunger pumps can operate with liquid viscosities up to several thousand centipoises as far as check valve operation goes. The usual difficulty is that the installation suppresses or starves the pump and it cavitates, functioning erratically because of unsatisfactory available NPSH.

If the suction line is increased to one size greater than the pump inlet, ¾-inch IPS (iron pipe size) or 0.824-inch I. D., H_d max will be much different.

$$\text{u max} = \frac{(3)(58)}{(229)} \quad \frac{(1.25)^2}{(0.824)} = 1.76 \text{ foot per second}$$

$$\frac{d\,(\text{u max})\,G}{C} = \frac{(0.824)\,(1.76)\,(0.85)}{20} 0.0176$$

$$H_i \text{ max} = \frac{(15)(1.76)(58)}{(307)}(1.2) = 6.0 \text{ feet}$$

$$H_f \text{ max} = \frac{(15)(1.76)(70)}{(646)(0.824)^2(0.85)} = 5.0 \text{ feet}$$

$$H_v \text{ max} = \frac{(1.76)^2}{32.2} = 0.1 \text{ foot}$$

$$H_d \text{ max} = \sqrt{6.0^2 + 5.1^2} = \sqrt{36 + 26} = \sqrt{62} = 7.9 \text{ feet}$$

Dynamic losses are thus found to be cut to less than half of the original value by increase from ½ to ¾-inch pipe size, all other conditions remaining the same.

Example 3—Pump Layout Problem

A feed rate of 2 gpm max of Ethyl Acetate solvent is required. Will a ¾-inch line be satisfactory if a run of 20 feet is required and minimum supply head is only 1 foot above the simplex pump inlet.

For Ethyl Acetate $P_v = 72.8$ mm H_g, or 1.41 psi
$G = 0.89$
$C = 0.46$ cp

$$\text{u max} = \frac{1.4\,\text{GPM}}{d^2} = \frac{(1.4)(2)}{(0.824)^2} = 4.13 \text{ feet per second}$$

$$\frac{d\,(\text{u max})\,G}{C} = \frac{(.824)\,(4.13)\,0.89}{.46} = 6.59$$

This is strongly turbulent flow and friction losses can be ignored.

$$H_d \text{ max.} = H_i \text{ max.} = \frac{N\,(\text{u max})}{4.3} = \frac{(20)\,(4.13)}{4.3} = 19.2 \text{ feet}$$

Installation is near sea level and P_s is taken at 14.2 psi minimum. The minimum available NPSH at pump inlet is determined as follows:

$$\text{NPSH} = 1.0 + \frac{2.31}{0.89}(14.2 - 1.4) - H_d$$

NPSH = 34.2 — 19.2 feet = 15 feet

The liquid would not vaporize. However, pressure will be well below atmospheric so the system should be carefully piped and operated.

Example 4—Pump Layout Problem

Suppose the liquid in Example 3 had been a concentrated caustic soda solution with a specific gravity of 1.53 and a viscosity of 60 centipoise. Would the same installation be satisfactory? The vapor pressure of the caustic solution is taken to be negligible at a pumping temperature of 90 F.

u max = 4.13 as in Example 3

$$\frac{d\,(\text{u max})\,G}{C} = \frac{(.824)\,(4.13)\,(1.53)}{60} = 0.087$$

This is streamline flow below the value of 0.14 and:

$$H_d \text{ max} = \sqrt{H_i \text{ max}^2 + (H_f \text{ max} + H_v \text{ max})^2}$$

H_i max = 19.2 feet as in Example 3

$$H_f \text{ max} = \frac{(20)(4.13)(60)}{(646)(0.678)\ 1.53} = 7.4 \text{ feet}$$

$$H_v \text{ max} = \frac{(4.13)^2}{32.2} = 0.5 \text{ feet}$$

$$H_d \text{ max} = \sqrt{19.2^2 + 7.9^2} = \sqrt{368 + 62} = 20.4 \text{ feet}$$

$$\text{NPSH} = 1 + \frac{2.31}{1.53}(14.2 - 0) - H_d$$

Min. available NPSH = 22.4 — 20.4 = 2.0 feet

This value is too close to typical pump NPSH requirements. Therefore, a 1 inch supply line should be used. This increase to 1 inch size will give a marked increase in minimum available NPSH.

$$\text{u max} = \frac{(1.4)(2)}{1.049^2} = 2.55 \text{ feet per second}$$

$$\frac{d\,(\text{u max})\,G}{C} = \frac{(1.049)\,(2.55)\,(1.53)}{(60)} = 0.068$$

$$H_i \text{ max} = \frac{(20)\,(92.55)}{4.3} = 11.9 \text{ feet}$$

$$H_f \text{ max} = \frac{(20)\,(2.55)\,(60)}{(646)\,(1.049)^2(1.53)} = 2.8 \text{ feet}$$

$$H_v \text{ max} = \frac{(2.55)^2}{32.2} = 0.2 \text{ foot}$$

$$H_d \text{ max} = \sqrt{(11.9)^2 + (3.0)^2} = 12.3 \text{ feet}$$

Min available NPSH = 22.4 — 12.3 = 10.1 feet

Independents Do Big Share of Oil Business

PETROLEUM REFINER study of oil company annual reports reveals that in 1955, small operators:

- **Refined 11 percent of all U. S. oil**
- **Produced 38 percent of all domestic crude**
- **Drilled 78 percent of all U. S. wells**

SMALL COMPANIES and independent operators with crude oil production and/or refinery runs averaging less than 10,000 barrels daily accounted for:

- Thirty-eight percent of all U. S. crude output in 1955, compared with 40 percent in 1954.
- Eleven percent of all U. S. refinery runs, compared with 13 percent in 1954.
- Seventy-eight percent of all domestic wells drilled, compared with 80 percent in 1954.

These figures for 1955 were obtained from a PETROLEUM REFINER study of all available annual reports of U. S. companies with refinery runs and/or crude production over 10,000 barrels daily.

Compared with earlier studies, the independents accounted for slightly smaller proportions of industry operations last year than in 1954. However, they had shown a significant increase in 1954 over 1953. The latest data show little difference from the proportions of U. S. operations accounted for by independents in 1953 and several prior years.

Strong competition in the U. S. oil industry is reflected in the ranking of companies in the industry as indicated in the adjacent table. In 1955, as in prior years, there were numerous changes in rank. Some companies achieved higher ranking than in the previous year. Conversely, other companies failed to hold their former rankings and took lower positions.

# #

Domestic Refinery Runs and Crude Oil Production of U. S. Companies in 1955

(Data from all available annual reports of U. S. companies with refinery runs and/or crude production above 10,000 barrels daily.)

COMPANY and RANK IN REFINING	CRUDE RUNS TO STILLS			CRUDE OIL PRODUCTION	
	Total Barrels	Barrels Daily	Percent of U.S.	Barrels Daily	Percent of Runs to Stills
(1-A) Standard (N.J.) U.S. Affiliates, Total	286,160,000	784,000	10.48	414,300	52.8
1. Standard (N.J.) Net Share of U.S. Affiliates	274,439,850	751,890	10.05	367,851	48.9
Esso Standard Oil Co.	188,705,000	517,000	6.91	.....	.....
87% of Humble O. & R. Co.	78,434,850	214,890	2.87	310,851	144.7
Carter Oil Co.	7,300,000	20,000	0.27	57,000	285.0
2. Standard Oil Co. (Indiana)	219,540,930	601,482	8.04	*274,083	45.6
3. Gulf Oil Corporation	214,572,000	587,867	7.86	230,731	39.2
4. The Texas Company	209,512,449	574,001	7.67	394,302	68.7
5. Socony Mobil Oil Company	199,126,845	545,553	7.29	260,327	47.7
6. Shell Oil Company	168,896,000	462,724	6.19	278,000	60.1
7. Standard Oil Co. of California	†168,698,278	†462,187	6.18	*269,261	58.3
8. Sinclair Oil Corp.	157,173,601	417,000	5.57	135,820	32.6
9. Cities Service Co.	96,225,000	263,628	3.53	126,296	47.9
(9-A) Humble Oil & Refining Co.	90,155,000	247,000	3.30	357,300	144.7
10. Sun Oil Company	87,136,964	238,729	3.19	115,376	48.3
11. Phillips Petroleum Company	83,458,345	228,653	3.06	*125,200	54.8
12. Atlantic Refining Co.	71,618,000	196,215	2.62	*101,518	51.7
13. Tide Water Associated Oil Co.	61,010,845	167,153	2.23	89,626	53.6
14. Pure Oil Company	60,492,335	165,731	2.22	66,859	40.3
15. Union Oil Co. of California	57,471,000	157,453	2.11	103,837	65.9
16. Continental Oil Company	53,170,645	145,672	1.94	*134,440	92.3
17. Standard Oil Co. (Ohio)	47,234,939	129,411	1.73	*31,406	24.3
18. Richfield Oil Corporation	44,508,000	121,940	1.63	56,791	46.6
19. Sunray Mid-Continent Oil Co.	36,281,030	99,399	1.33	*80,121	80.6
20. British American Oil Co.	35,676,000	97,742	1.31	28,753	29.4
21. Skelly Oil Company	17,044,574	46,587	0.62	68,014	146.0
22. The Ohio Oil Company	15,483,780	42,421	0.57	98,404	232.0
23. Plymouth Oil Company	11,345,000	31,082	0.42	17,647	56.8
24. Delhi-Taylor Oil Corporation	10,300,000	28,219	0.38	3,825	13.6
25. Clark Oil and Refining Corp.	8,335,468	22,837	0.30	.....	.....
26. Colorado Oil and Gas Corp.	4,804,913	13,164	0.18	4,145	31.5
27. South Penn Oil Company	3,208,715	8,791	0.11	10,254	116.6
‡Total, 27 Companies	2,428,485,656	6,639,641	88.76	3,519,336	53.0
Remainder of Industry	301,732,344	840,359	11.24	3,287,664	391.2
Total, United States	2,730,218,000	7,480,000	100.00	6,807,000	91.0

* Includes natural gas liquids. † Total Western Hemisphere. ‡ Includes Item (1-A) for Standard (N.J.); excludes other data on that company and its subsidiaries, Esso Standard, Humble, and Carter.

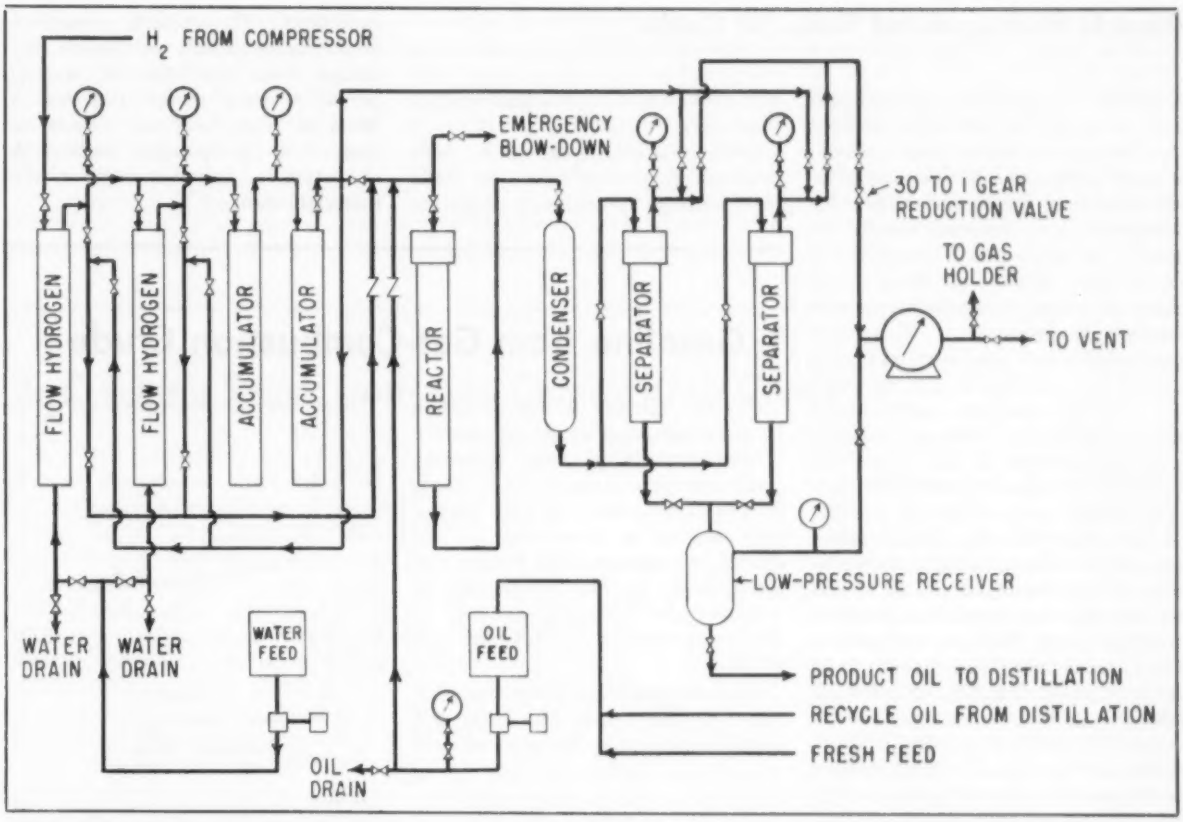


FIGURE 1—The high sulfur, nitrogen, and oxygen content of shale-oil crudes may be reduced by recycle hydrogenation. Here is the flow diagram of the process which was used to obtain these data.

Recycle Hydrogenated Shale-Oil Crude

These pilot plant studies show that recycle hydrogenation of shale oil crudes produces gasoline and cat cracking stock of good quality.

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U. S. Bureau of Mines, Laramie, Wyoming

RECYCLE DESTRUCTIVE hydrogenation at 3000 pounds per square inch and 890 F. of shale oil from the gas-combustion retort produces 106 volume percent of stable, low-sulfur, low-nitrogen naphtha that would be suitable as a catalytic reforming feed stock. At lower temperature, the product is less volatile, and most of it is obtained as a 725 F. end-point catalytic cracking stock. Fixed-bed catalytic cracking of this stock produces a gasoline with 92 unleaded-research octane number in approximately the same yield that is obtained from East Texas light gas oil.

Recycle destructive hydrogenation of high-temperature shale oil from retorting at 1200 F. produces 99 volume percent of stable, low-sulfur, low-nitrogen gasoline having 89 leaded-research octane. Composition of this gasoline indicates that it also should be a satisfactory catalytic reforming stock.

Sulfur, nitrogen, and oxygen derivatives of hydrocarbons occur in such large proportions in Colorado

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shale oils—for example, over 60 percent of an N-T-U oil[6]—as to necessitate destruction rather than removal, if good yields of liquid fuels are to be obtained from this source. Several investigators have reported results obtained in single-pass hydrogenation of this type of shale oil. Hoog et al,[8] using a cobalt-molybdenum-carrier catalyst at pressures of 50 to 150 atmospheres and temperatures of 375 to 475 C., and Smith and co-workers,[11] using a tungsten sulfide-nickel sulfide catalyst at 3000 psi pressure and temperatures in the range 690 to 770 F., produced good diesel fuels and smaller percentages of gasoline of low octane number. Better nitrogen removal and reduction in quantity of high-boiling fractions would be desirable in preparing catalytic cracking stocks. Pelipetz and associates,[9] using cobalt-molybdate and tungsten-sulfide catalysts at 9000 psi pressure and temperatures in the range 750 to 950 F., produced an oil essentially free of sulfur and nitrogen and suitable for further processing by standard petroleum methods.

The purpose of the present work was to study recycle hydrogenation at 3000 psi pressure of raw crude shale oils (1) to prepare a maximum of gasoline-boiling-range material from shale oil produced in the gas-combustion retort of the Bureau of Mines at Rifle, Colo.; (2) to prepare a maximum of 700 F. end-point catalytic cracking stock from this crude; and (3) to prepare a maximum of gasoline-range material from shale oil produced at 1200 F. by the entrained-solids method of the Bureau of Mines at Laramie, Wyo.

Properties of the shale-oil crudes produced by the Bureau of Mines in the gas-combustion and entrained-solids retorts are given in Table 1. As shown by the properties, retorting at 1200 F. in the entrained-solids retort produces a lower gravity oil which contains more sulfur and nitrogen compounds and has a lower boiling-range distribution than does gas-combustion crude. Dinneen[7] has shown that shale oil from retorting at 1200 F. also contains a much higher percentage of aromatic compounds than oil from retorting in lower temperature retorts such as the gas-combustion retort.

Before each recycle study with these oils, single-pass runs were made to determine approximate operating conditions. To establish reaction equilibria as rapidly as possible, the charge stock used for the startup period of each recycle run was a blend of fresh feed and recycle oil from these preliminary studies. A correction for this was made in the material balance.

1. Gasoline from Gas-Combustion Crude

For the destructive hydrogenation of gas-combustion crude to produce a maximum of gasoline, operating conditions were those shown in Table 2. The recycle ratio of 1.03 gave a high degree of conversion of the charge to gasoline-range boiling material, with the net production of little recycle oil. About one-half of the gas produced was C4-plus material.

The run was divided into test periods of six hours each. The sulfur and nitrogen contents of the gasoline were determined for the different periods, and the results are shown in Figure

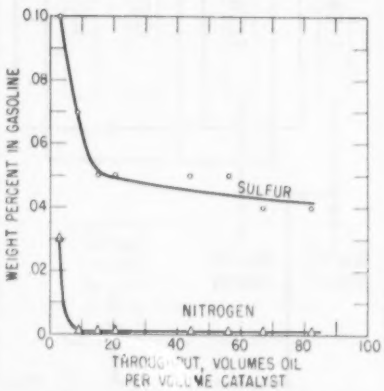

FIGURE 2—Equilibrium conditions of sulfur and nitrogen in the product were obtained after the first six-hour test period.

TABLE 1

Properties of Shale-Oil Crudes

	Gas-Combustion Crude	1200 F—Retort Crude
ASTM, Distillation, F.:		
IBP	273	149
5 percent	369	195
10 percent	427	221
20 percent	548	281
30 percent	621	350
40 percent	664	448
50 percent	695	525
60 percent	716	614
70 percent	733	659
End point	733	664
Recovery, volume percent	70.0	73.0
Loss, volume percent	2.0	1.5
Gravity, °API	19.2	14.3
Sulfur, weight percent	0.67	0.95
Nitrogen, weight percent	2.10	3.22
Viscosity, SUS, 100 F.	311	.....
Pour point, F.	79	35

TABLE 2

Hydrogenation of Gas-Combustion Crude to Produce Gasoline

Operating Conditions:	
Temperatures:	
Catalyst, average F.	889
Catalyst, maximum F.	893
Pressure, p.s.i.g.	3,000
Space velocity, Vo/Vc/hr.	0.98
Throughput, Vo/Vc	82.16
Hydrogen feed rate, SCF/bbl.	6,000
Hydrogen consumption SCF/bbl. of fresh feed	2,040
Recycle ratio, recycle/fresh feed	1.03
Material Balance, Percent of Fresh Feed:	
Gasoline, volume percent	99.3
Recycle oil, weight percent	1.7
Water, weight percent	2.0
Catalyst deposit, weight percent	0.2
Gas, total, weight percent	13.8
C4-plus in gas, volume percent	7.5
C4-plus gasoline, volume percent	106.8
Loss, weight percent	2.3

TABLE 3

Gasoline Prepared From Gas-Combustion Crude

	Gasoline	Recycle Oil
ASTM, Distillation, F.:		
IBP	103	.....
5 percent	136	.....
10 percent	159	.....
20 percent	190	.....
50 percent	272	.....
90 percent	374	.....
End point	404	.....
Recovery, volume percent	95.0	.....
Loss, volume percent	4.2	.....
Gravity, °API	57.6	39.7
Sulfur, weight percent	0.05	0.06
Nitrogen, weight percent	nil	0.03
Tar acids, volume percent	0.0	.....
Tar bases, volume percent	0.2	.....
Doctor test	sweet	.....
Cu. strip corrosion	None	.....
Composition, Volume Percent:		
Paraffins	50	.....
Naphthenes	30	.....
Olefins	7	.....
Aromatics	13	.....
Reid vapor pressure, p.s.i.	11.0	.....
Gum, ASTM, mg./100 ml.	1.8	.....
Gum, Cu. dish, mg/100 ml.	11.5	.....
Induction period, hours	24+	.....
Aniline point, F.	.....	170.2
Diesel index	.....	67.6
Octane, F-2, clear	48	.....
Octane, F-2, + 1 ml. TEL	62	.....
Octane, F-2, + 3 ml. TEL	73	.....
Octane, F-1, clear	51	.....
Octane, F-1, + 1 ml. TEL	64	.....
Octane, F-1, + 3 ml. TEL	76	.....

2. Although percentages of these elements were low throughout the run, they were somewhat higher in the first sample than in later samples, indicating that equilibrium conditions were attained by the end of the first six-hour test period.

A composite sample was prepared which consisted of all gasoline produced after the first six hours of operation. Properties of this gasoline are given in Table 3. It contained little sulfur or nitrogen and had low gum content and excellent oxidation stability; the hydrocarbons consisted mainly of paraffins and naphthenes. Clear motor and research octane numbers were very low, but by adding 3 ml. of tetraethyllead these were increased to 73 and 76 respectively. Although the octane ratings are lower than modern engine requirements, the gasoline would be suitable for blending purposes or for catalytic-reforming charge stock.

The small quantity of recycle oil contained little sulfur and nitrogen, and the diesel index of 67.6 indicated that it could be used as high-cetane diesel fuel, if desired.

2. Cracking Stock from Gas-Combustion Crude

For the preparation of catalytic cracking stock by recycle hydrogenation of gas-combustion crude, a product having an end point in the range 700 to 725 F. was chosen. This was done partly because of the non-hydrocarbon nature of the higher boiling oil, as shown by Cady and Seelig,[5] and partly because of difficulties encountered in the handling of a heavier recycle stock obtained in preliminary experiments.

For this work, it was desired to avoid the production of large quantities of low-octane naphtha; therefore, a reaction temperature of only 784 F. was used. This was 105 F. lower than had been used for the destructive hydrogenation of this oil, but other conditions, shown in Table 4, were similar to those used in the preceding run, although recycle ratio was of necessity somewhat lower because of the difference in cutpoints of the products. The recycle ratio of 0.87 was used after measurement of products during the early part of the run indicated that a ratio of 1.0 caused the recycle stock to be consumed more rapidly than it was being produced. An accumulation of 10.4 volume percent of recycle stock during the run indicated that a recycle ratio somewhere between these two values would have been more nearly appropriate.

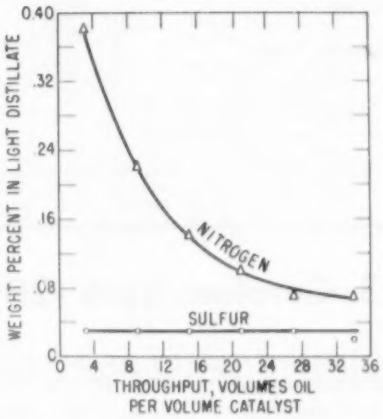

FIGURE 3—Recycle hydrogenation of gas-combustion crude at mild temperature yields a low-nitrogen catalytic cracking stock.

Yield of hydrogenated distillate was high, 94.5 volume percent; as indicated by the preceding discussion, this could have been increased several more percent through proper adjustment of the recycle ratio. Total liquid yield was 104.9 percent, and gas yield was very low, only 2.4 weight percent.

To establish the time required to obtain equilibria, the run was divided into test periods of six hours each. Limited data were obtained on the product from each period. These data, presented in Table 5 and Figure 3, show that more time was required to establish equilibrium for nitrogen removal than was required in the hydrogenation at high temperature, and the nitrogen removal was not as complete. Nitrogen content of the product changed greatly during the first 18 hours of operation but showed little change during the last 16 hours.

Catalytic cracking studies were made of the oil from each test period, with the results shown in Table 6. The complete distillate fractions, which included approximately 25 percent naphtha, were charged to the cracking unit; undoubtedly the naphtha in the charge stock contributed to the high gas production observed during most of the catalytic cracking runs.

Nitrogen content of the charge distillate had a marked effect on the

TABLE 4
Hydrogenation of Gas-Combustion Crude to Produce Cracking Stock

Operating Conditions:	
Temperatures:	
Catalyst, average, F	784
Catalyst, maximum, F	789
Pressure, p.s.i.g.	3,000
Space velocity, Vo/Vc/hr.	1.02
Throughput, Vo/Vc	34.57
Hydrogen feed rate, SCF/bbl.	6,000
Hydrogen consumption, SCF/bbl. of fresh feed	1,540
Recycle ratio, recycle/fresh feed	0.87
Material Balance, Percent of Fresh Feed:	
Light distillate, volume percent	94.5
Recycle oil, volume percent	10.4
Water, weight percent	0.6
Gas, weight percent	2.4
Catalyst deposit, weight percent	0.5
Loss, weight percent	0.7

TABLE 5—Cracking Stock Produced From Gas-Combustion Crude

TEST PERIOD	1	2	3	4	5	6
Volume oil/volume catalyst	6.0	12.0	18.0	24.0	30.0	34.57
ASTM, Distillation, F.:						
IBP	176	187	179	167	170	156
5 percent	261	257	240	241	255	272
10 percent	334	303	272	294	299	303
50 percent	542	491	513	539	539	528
90 percent	687	656	647	681	690	683
End point	701	705	681	721	726	721
Recovery, volume percent	97.0	97.1	96.8	97.5	97.2	97.0
Loss, volume percent	1.1	1.0	1.4	1.0	1.1	1.2
Gravity, °API	37.7	38.4	38.7	37.9	38.1	37.9
Sulfur, weight percent	0.03	0.03	0.03	0.03	0.03	0.02
Nitrogen, weight percent	0.38	0.22	0.14	0.10	0.07	0.07
Composition, Volume Percent:						
Paraffins + naphthenes	69	70	70	67	69	70
Olefins	5	3	2	2	2	0
Aromatics	26	27	28	31	29	30

quantity of cracked gasoline produced. Over the range of nitrogen contents studies and under the cracking conditions employed, the yield of new gasoline (Figure 4) appears to be an inverse linear function of the nitrogen content. For those samples in which nitrogen was reduced to 0.10 percent or less, including all samples after the eighteenth hour of operation, new cracked gasoline yield was nearly as great as would be obtained from East Texas gas oil under similar conditions. Average yield of total gasoline in the product from single-pass catalytic cracking of these three samples was 57.4 volume percent of the cracking stock or 54.2 percent of the original crude oil.

Product gasolines from catalytic cracking of the light distillates from test periods 4 through 6 were combined, and properties of the composite gasoline are shown in Table 7. Octane number of the gasoline was not as high as would be expected for catalytically cracked gasoline, owing to the low-octane hydrogenated gasoline present in the charge stock; however, if it is assumed that the gasoline portion of the charge went through the cracking unit unchanged, with octanes similar to those shown in Table 3, calculation shows that unleaded blending research octane of the new cracked gasoline would have to be 92 to produce the 74-octane product that was obtained.

TABLE 6—Catalytic Cracking the Stocks Produced From Gas-Combustion Crude

Conditions:	43-Activity Silica-Alumina					
Catalyst						
Temperature, F.	800					
Catalyst to Oil Ratio	4:1					
Space Velocity, Vo/Vc/hour	1.1					
TEST PERIOD	**1**	**2**	**3**	**4**	**5**	**6**
Charge Oil:						
Nitrogen, weight percent	0.38	0.22	0.14	0.10	0.07	0.07
Gasoline, volume percent	24.8	26.4	27.2	26.4	26.4	25.4
Material Balance:						
Gasoline, volume percent	45.8	52.3	55.4	56.5	58.2	57.6
Gas oil, volume percent	40.2	35.2	30.9	29.6	30.0	28.5
Gas, weight percent	11.7	13.3	13.7	14.4	14.0	14.9
Catalyst deposit, weight percent	6.1	4.8	5.0	5.2	4.7	4.5
Conversion, volume percent	46.5	52.2	57.6	59.8	59.2	60.4
Gasoline produced, volume percent of +400 °F. charge	27.9	35.2	38.7	42.2	43.2	43.1

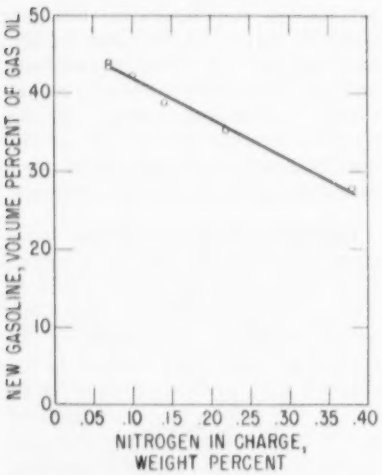

FIGURE 4—The yield of gasoline from hydrogenated crude is related to the nitrogen content of the cat charge.

TABLE 7
Catalytically Cracked Gasoline

ASTM Distillation, F.:	
IBP	99
5 percent	122
10 percent	139
20 percent	158
50 percent	255
90 percent	364
End point	405
Recovery, volume percent	95.5
Loss, Volume percent	3.4
Gravity, °API	57.9
Sulfur, weight percent	0.03
Nitrogen, weight percent	nil
Gum, Cu. dish, mg/100 ml.	1.6
Composition, Volume Percent:	
Paraffins	53
Naphthenes	17
Olefins	6
Aromatics	24
Octane, F-2, clear	69
Octane, F-1, clear	74
Octane, F-1, + 3 ml. TEL	90

3. Gasoline from 1200 F-Retort Crude

Operating conditions and material balance for the recycle destructive hydrogenation of 1200 F. crude are given in Table 8. To produce a gasoline with as high an octane rating as possible, average reaction temperature was maintained at 903 F. This is about the highest level that single-pass experiments show to be consistent with good liquid yields at the space velocity of 1.0 volume of oil per volume of catalyst per hour. Under these conditions 91.2 volume percent of the crude was converted to gasoline, and only 3.2 percent was obtained as recycle stock. The low percentage of recycle stock indicated that the recycle ratio of 0.60 was approximately the maximum that could be used for continuous operation.

The run was divided into nine test periods to permit determining the variation of sulfur and nitrogen content of the hydrogenated gasoline during the course of the run. The data (Figure 5) show that nitrogen content decreased greatly with increased throughput, but sulfur content changed only slightly.

TABLE 8
Hydrogenation of 1200 F—Retort Crude

Operating Conditions:	
Temperatures:	
Catalyst, average F.	903
Catalyst, maximum F.	911
Pressure, psig	3,000
Space velocity, Vo/Vc/hr.	1.00
Throughput, Vo/Vc	34.17
Hydrogen feed rate, SCF/bbl.	6,000
Hydrogen consumption, SCF/bbl. of fresh feed	2,450
Recycle ratio, recycle/fresh feed	0.60
Material Balance, Percent of Fresh Feed:	
Gasoline, volume percent	91.2
Recycle oil, volume percent	3.2
Water, weight percent	1.5
Catalyst deposit, weight percent	0.8
Gas, weight percent	17.9
C_4-plus in gas, volume percent	8.1
C_4-plus gasoline, volume percent	99.3
Loss, weight percent	1.1

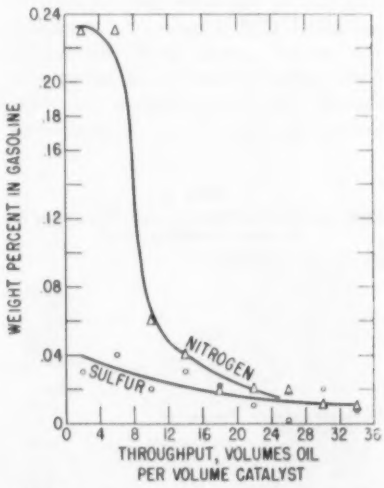

FIGURE 5—Recycle hydrogenation of the 1200F-retort crude produces a motor fuel blending stock of good quality.

Properties of the blended gasoline are given in Table 9. The blend consisted of products from test periods in which the nitrogen content was less than 0.10 percent and included gasoline from all but the first 8 hours of the run. The blend was analyzed for hydrocarbon types and was found to contain 36 percent of aromatic hydrocarbons. Part of it was separated into close-boiling fractions, which were analyzed with the mass spectrometer for individual aromatic compounds; it was found that three components, benzene, toluene, and xylenes, composed over 10 percent of the gasoline. The gasoline was water-white, was color stable, and had no objectionable odor. The octane ratings of 67 and 75, clear motor and research method, and 84 and 89, respectively, with 3 ml. of tetraethyl-lead, were far superior to those reported for gasoline obtained by hydrogenation of low-temperature shale oils.

TABLE 9
Gasoline From 1200 F—Retort Crude

ASTM Distillation, F.:	
IBP	112
5 percent	151
10 percent	168
20 percent	187
50 percent	258
90 percent	359
End point	417
Recovery, volume percent	97.1
Loss, volume percent	2.0
Gravity, °API	49.5
Sulfur, weight percent	0.02
Nitrogen, weight percent	0.02
Tar acids, volume percent	0.0
Tar bases, volume percent	0.2
Doctor test	sweet
Cu. strip corrosion	none
Reid vapor pressure, psi	10.2
Gum, ASTM, mg/100 ml.	4.0
Gum, Cu. dish, mg./100 ml.	13.1
Induction period, hours	24+
Composition, Volume Percent:	
Paraffins	38
Naphthenes	23
Olefins	3
Aromatics, total	36
Benzene	4.2
Toluene	4.1
Xylenes	2.1
Octane, F-2, clear	67
Octane, F-2, + 3 ml. TEL	84
Octane, F-1, clear	75
Octane, F-1, + 3 ml. TEL	89

ACKNOWLEDGMENT

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Here's a description of equipment and methods used . . .

A simplified flow diagram of the hydrogenation equipment is shown in Figure 1. The catalyst charge of 150 cc. was placed in a 1-inch diameter catalyst bed near the bottom of the reactor, and the upper or preheating section was filled with inert alundum grain. Thermocouples placed in a central thermowell were located in the catalyst bed at three-inch intervals, and temperatures were maintained by means of automatically controlled electric heating elements which surrounded the reactor.

Hydrogen obtained from standard shipping cylinders was compressed to 3000 psi in the flow-hydrogen storage cylinders and to 5000 psi in the hydrogen accumulators. At the beginning of the run the pressure in the reaction system was adjusted to 3000 psi with hydrogen from the accumulators. After oil feed was begun, metered water containing sodium chromate as a corrosion inhibitor was pumped into one of the flow-hydrogen cylinders to displace hydrogen into the reaction system at a known rate. When one flow cylinder was depleted, hydrogen was displaced from the second in a similar manner while the first was being drained of water and repressurized from the accumulator vessels.

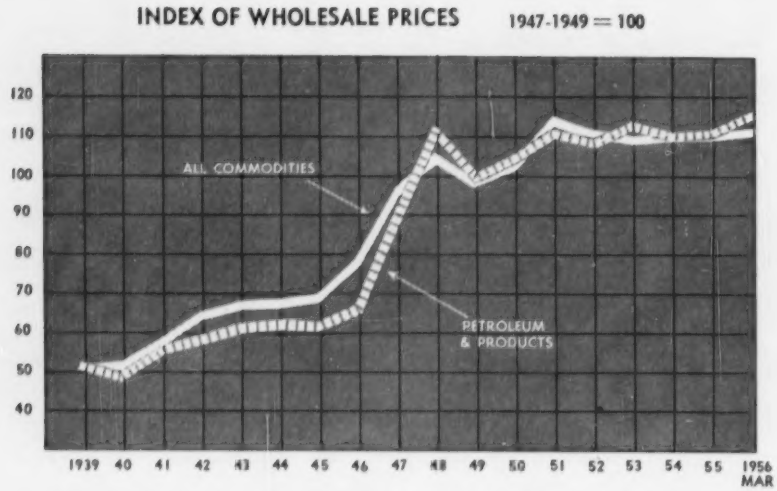
Product oil was collected in one of two high-pressure separators which were placed on stream for alternate two-hour periods. They were drained to a low-pressure separator at the end of each period. Repressurizing of these vessels with hydrogen from the accumulator before they were placed on stream eliminated fluctuations in pressure and space velocity. Gas withdrawn from the separators was regulated manually by means of a 30-to-1 gear reduction valve which permitted minute changes in gas-withdrawal rates. After the gas was metered, it was sampled with a proportional sampling device and vented. Liquid product was charged to a continuous steam distillation column from which the desired product was taken overhead and recycle oil was removed as bottoms. Recycle oil was mixed with fresh feed in the proper proportions before it was placed in the charge burette.

Cracking tests of catalytic cracking stock were made with a catalytic-activity testing unit similar to that described by Alexander.[1]

The hydrogenation catalyst was cobalt molybdate of the type described by Byrnes and co-workers[4] and was obtained in 3/16-inch pellets. These were crushed and sized to pass 6-mesh and be retained on 8-mesh screens. It was regenerated with air *in situ* after each run and had a history of several hundred hours operation before these investigations.

Catalytic cracking investigations were made with 43-activity-index, synthetic silica-alumina pellets.

The analytical methods were standard ASTM procedures whereever practicable. Hydrocarbon-type analyses on product oils were determined by silica gel adsorption,[5] and octane ratings were obtained by the micro-method described by Alexander and Pfeiffer.[2] Hydrogen consumptions were calculated from the ultimate analyses of the charge and products. Catalyst deposits were determined from carbon dioxide sorption on Ascarite during regeneration of the hydrogenation catalyst. The mass spectrometer was used for analyzing gases and pure aromatics in the gasoline from hydrogenation of the high-temperature crude.



Higher Prices in General Would Support Higher Oil Prices

Prices of petroleum and products traditionally stick close to the trend of prices of all commodities in the aggregate. All commodities are likely to increase around midyear. If they do, oil prices probably would, too.

Will Oil Prices Go Up?

THE ANSWER to this question may be determined mainly by the future trend of prices of commodities in general. If prices in general go higher, as they now seem likely to do, then prices of petroleum and products probably will go up, too.

As shown in a chart and tables herewith, prices of oils in the past have stuck very close to the trend of prices of all commodities in the aggregate.

Since last fall, prices of all commodities combined and prices of petroleum products have been moderately increasing. Oils have increased somewhat more than other commodities.

If prices of oils are to increase substantially in coming months and hold at the higher levels, they probably will do so only with the support of similarly higher prices of other commodities.

The stage may be about set for this to happen. It is indicated that a new general wage-price increase may be sparked at midyear by the steel industry. Steel wages are expected to be raised 15 to 20 cents an hour and steel prices about $10 a ton. Subsequently, wage and price increases may occur in many other lines, as in the past when steel led the way.

Higher prices for oils around midyear might be in line with the trend of prices of commodities in general.

Higher prices for oils would be justified by past and prospective increases in costs of labor and materials and the increased costs of finding and developing oil reserves.

Heretofore, in spite of higher costs, prices in the oil industry have been held down, partly because of the pressure of ample supplies of domestic and foreign crude. However, continued increases in costs now threaten to curtail supply. Higher prices for oils now seem more necessary to bring forth adequate supplies for the future.

Index of Wholesale Prices

(All Commodities vs. Crude Petroleum and Petroleum Products.)

Source: U. S. Bureau of Labor Statistics. 1947-1949 = 100

YEAR	All Commodities	Crude Oil & Products	YEAR	All Commodities	Crude Oil & Products
1926	65.0	98.1	1942	64.2	58.7
1927	62.0	71.3	1943	67.0	61.4
1928	62.9	70.6	1944	67.6	62.7
1929	61.9	69.9	1945	68.8	62.4
1930	56.1	60.4			
			1946	78.7	86.3
1931	47.4	38.7	1947	96.4	88.2
1932	42.1	44.5	1948	104.4	111.7
1933	42.8	40.2	1949	99.2	100.1
1934	48.7	49.5	1950	103.1	103.7
1935	52.0	50.3			
			1951	114.8	110.5
1936	52.5	56.2	1952	111.6	109.3
1937	56.1	59.3	1953	110.0	112.7
1938	51.1	54.9	1954	110.3	110.8
1939	50.1	51.3	1955	110.7	112.7
1940	51.1	49.1			
			1955: Dec.	111.3	115.6
1941	56.8	56.0	1956 Mar.	112.9	117.5

U. S. Average Prices of Gasoline in 50 Cities, by Years

Source: The Texas Co., via API. Cents per Gallon

YEAR	Service Sta. Excl. Tax	Service Sta. Incl. Tax	YEAR	Service Sta. Excl. Tax	Service Sta. Incl. Tax
1918	25.12	25.12	1938	14.07	19.51
1919	25.41	25.47	1939	13.31	18.75
1920	29.74	29.83	1940	12.75	18.41
1921	26.11	26.31	1941	13.30	19.23
1922	24.82	25.20	1942	14.46	20.43
1923	21.06	21.97	1943	14.56	20.53
1924	19.46	20.94	1944	14.62	20.59
1925	20.09	22.20	1945	14.48	20.50
1926	20.97	23.38	1946	14.69	20.77
1927	18.29	21.09	1947	16.93	23.11
1928	17.90	20.94	1948	19.54	25.88
1929	17.92	21.42	1949	20.27	26.79
1930	16.17	19.95	1950	20.08	26.76
1931	12.98	16.98	1951	20.31	27.15
1932	13.30	17.93	1952	20.24	27.56
1933	12.41	17.82	1953	21.28	28.69
1934	13.64	18.85	1954	21.56	28.95
1935	13.55	18.84	1955	21.42	29.07
1936	14.10	19.45	1955 Dec.	21.20	29.00
1937	14.59	19.99	1956 Mar	21.32	29.12

Crude Price Changes in Mid-Continent, California, and West Texas, by Years (Dollars Per Barrel)

DATE	Okla., Kans. 36-36.9° Gravity	Calif., Long Beach 27-27.9°	West Texas Sour 30-30.9°
1937. Prior to Jan. 1	$1.10	$1.10	$0.78
January 28	1.22	....	0.88
1938: October 12	1.02	....	0.75
1939: No Changes	....	....	....
1940: February 1	....	1.03	....
1941: March 29	....	....	0.82
April 1	1.07	....	....
April 24	....	1.09	....
May 20	1.17	....	....
May 21	....	....	0.92
May 23	....	1.15	....
1942: Feb. 3: frozen at Oct. 1, 1941 level	1.17	1.15	0.92
1943; 1944; 1945: No Changes; prices frozen	....	....	....
1946: April 1: OPA Raise	1.27	1.25	1.02
July 25· Oil Prices decontrolled	1.52	....	1.27
August 1	....	1.50	....
November 15	1.62	....	....
November 19	....	....	1.37
1947: March 10	1.87	....	1.62
March 19	....	1.75	....
July 1	....	1.95	....
October 15	2.07	....	....
October 16	....	....	1.82
December 6	2.57	....	2.32
December 27	....	2.45	....
1948: No Change	....	....	....
1949: June 1	....	2.37	....
1950: December 12	....	2.41	....
1951: Frozen at Jan. 25 level	2.57	2.41	2.32
1952: No Changes; Frozen	....	....	....
1953: Feb. 16; decontrolled	....	2.76	....
June 15	2.82	....	2.32
1954: No Change	....	....	....
1955: No Change	....	....	....
1956: No Change	....	....	....

How to Design Cooler-Condensers

This method eliminates the mass transfer coefficient from the design equation. A graphical determination of the gas-liquid interface replaces trial-and-error calculations.

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THE COOLING and condensation of saturated gases is a very important unit operation in the process industries. The design of tubular cooler-condensers has long been a tedious and difficult problem. This article offers a simplified design method.

The Colburn-Hougen method has been simplified. Introducing the factor, $F' = (L_v/C_m)\ (Pr/Sc)_,^{2/3}$ permits the elimination of the mass transfer coefficient from the design equation. This reduces the number of physical constants that need be calculated from point to point. A graphical determination of the gas-liquid interface conditions replaces the trial and error calculations of the Colburn-Hougen method.

A sample calculation using the simplified procedure is given. A cooler-condenser for a saturated mixture of carbon dioxide and water vapor is designed. Tube area calculations using this simplified method show only 0.5 percent error compared with the trial and error Colburn-Hougen method.

The same example calculated by Cairns' approximation method resulted in an error of + 27 percent in tube area.

Present Design Methods—When a gas-vapor mixture is in contact with a cold tube surface with temperature below the dew-point of the gas mixture, simultaneous heat and mass transfer occurs. In a tubular cooler-condenser both mass and heat are transferred in the direction of the tubes. The rate of this transfer depends upon the coefficients and the driving forces available. For the design of cooler-condensers these coefficients must be calculated and the driving forces determined.

Except for the direction of heat and mass transfer and absence of tube walls, the mechanism of transfer in a cooler-condenser can be compared with that encountered in a water cooling tower. Attempts have been made to develop a design procedure for cooler-condensers similar to that used for water cooling towers. Heat and mass transfer coefficients were combined in a single coefficient for the enthalpy or total heat in this method first proposed by Merkel.[1] The principle has been developed for the design of tubular dehumidifiers by Goodman,[2] Mickley,[3] and others. In deriving the design equation on this basis, it is assumed that mass transfer is proportional to the difference in absolute humidity and the ratio of Prandtl and Schmidt numbers equals unity. The first assumption is approximately true for cooling towers. The second is about correct for the system air-water vapor but in great error for some other gas-vapor mixtures. This enthalpy design method can not be used generally for the design of cooler-condensers.

Mizushina and Kotoo[4] have presented a design method for gas-vapor mixtures with Prandtl-Schmidt number ratio deviating from unity. This method uses a modified enthalpy. The driving force for enthalpy transfer at several intermediate points is found by a graphical stepwise procedure in a diagram of modified enthalpy versus temperature. Tube surface area is calculated by graphical integration. This method is more complicated than Merkel's method. Like Merkel, Mizushina and Kotoo assume that mass transfer is proportional to the difference in absolute humidity. Therefore, this method cannot be used as a general design method for the calculation of cooler-condensers.

Colburn and Hougen[5] have shown that the mass velocity in cooler-condensers may vary due to condensation of a part of the vapors. Therefore, they recommend calculating the over-all heat transfer coefficient at several

intermediate points in the cooler, by trial and error solution of the equation,

$$h_o (t_c - t_w) = h_g (t_g - t_c) + k_g \lambda (p_v - p_c) = U (t_g - t_w) \quad (1)$$

The values of the heat and mass transfer coefficients can be computed from data in the literature, e.g., Chilton and Colburn's[18] heat and mass transfer correlations,

$$h_g = \frac{j_H \, c \, G}{Pr^{2/3}} \quad (2)$$

$$k_g = \frac{j_M \, G \, M_v}{M_m \, p_{gf} \, Sc^{2/3}} \quad (3)$$

The value of $j_H = j_M$ can be obtained from graphs, presented in the original literature.

In Equation (1), h_o is the combined heat transfer coefficient for the cooling water, tube wall, condensed liquid, and dirt and scale layers, or

$$h_o = \frac{1}{\frac{1}{h_L} + \frac{1}{h_w} + \frac{1}{h_c} + \frac{1}{h_d}} \quad (4)$$

In saturated gas-vapor mixtures, the relation between the gas temperature, t_g, and the cooling water temperature, t_w, can be calculated by a simple heat balance.

The direct solution of Equation (1) is not possible. Trial and error calculations are required because:

- The saturated vapor pressure of the condensed liquid, p_c, is a function of the temperature, t_c.
- The mass transfer coefficient, k_g, depends on the logarithmic mean value of the inert gas, p_{gf}.

When several intermediate values for the heat flux, $U\Delta t_{ov}$, have been obtained by the solution of Equation (1), the condenser tube area required can be calculated by a graphical integration of the equation,

$$A = \int dA = \int \frac{dQ}{U (t_g - t_w)} \quad (5)$$

Integrate this equation by plotting values of the total heat transferred, Q, against $1/U (t_g - t_w)$, and measuring or calculating the area under the integration curve from the zero ordinate.

The Colburn and Hougen method is a laborious trial and error procedure. The author[6] shows that the trial and error calculations can be shortened by a graphical solution of Equation (1). He shows that Equation (1) can be transformed into an equation of the form,

$$\frac{p_v - p_c}{t_c - t_B} = \frac{R_h + 1}{R_m} \quad (6)$$

$$\text{where, } t_B = t_w + \frac{R_h}{R_h + 1} (t_g - t_w) \quad (7)$$

$$R_h = h_g / h_o \quad (8)$$

$$R_m = k_g \lambda / h_o \quad (9)$$

A straight line through point $t = t_B$, $p = p_v$, having a slope of minus $(R_h + 1)/R_m$, will intersect the saturated curve at the point t_c, p_c on a temperature-partial vapor pressure diagram. This method still requires trial and error because k_g and R_m vary with p_{gf}. Usually only one or two trials are required compared to three to five with the older method.

Colburn[7] has proposed to use the enthalpy potential as the basis for the design of cooler-condensers. The condenser tube area is calculated with the equation,

$$A = \frac{Q}{(U_s/c_s) \, \Delta i_m} \quad (10)$$

In this equation, (U_s/c_s), is calculated as the arithmetic mean of the two terminal values of the condenser, where

$$\frac{c_s}{U_s} = \frac{c_s}{h_g} + \frac{m}{h_o} \quad (11)$$

The method is much simpler than the original Colburn and Hougen method. Cairns[8] has pointed out that Colburns enthalpy method gives deviations of more than 80 percent in some cases. Although the method gives closer results in other cases, it is obvious that it can not be used as a general design method for cooler-condensers.

Cairns[8] has then proposed to solve Equation (5), by assuming that $U \Delta t_{ov}$ is a function of Q, or

$$U \Delta t_{ov} = a Q^2 + bQ + c \quad (12)$$

When three values for $U \Delta t_{ov}$ are obtained by trial and error calculations ($Q = 0$, $Q = 0.5 \, Q_{tot.}$, and $Q = Q_{tot.}$), the three constants a, b, and c can be calculated. The integration of Equation (5) after substitution of Equation (12) can be made analytically or by using the graph published by Carey and Williamson.[9] Cairns' method gives very good results in 4 out of 5 examples of cooler condensers for saturated gas-vapor mixtures tested, but shows a deviation of minus 42 percent in another example.

Cairns' method can only be applied to saturated gas-vapor mixtures, because for non-saturated mixtures the value of $U \Delta t_{ov}$ at $Q = 0.5 \, Q_{tot}$ can not be calculated in advance. The author has checked this method for a number of other examples of cooler-condensers for saturated mixtures. The deviations as compared with Colburn and Hougen's standard method were found between plus 27 percent and minus 27 percent. One of the examples will be given later together with a more detailed discussion of Cairns' method.

In view of this situation, it was thought useful to investigate the Colburn-Hougen method again, to check the possibilities of further simplifications or approximations. This article is the result of the investigation.

Simplified Design Method—Use of the Colburn-Hougen design method is a trial-and-error procedure. Further impairment is the point to point determination of many physical constants and coefficients.

Before Equation (1) can be solved, numerical values for the following constants must be available—

1. Reynolds number, Re
2. Viscosity of Gas-vapor mixture, μ
3. Heat transfer factor, j
4. The specific heat of the gas-vapor mixture, c
5. The gas mass velocity, G
6. The thermal conductivity, k
7. The Prandtl number, Pr
8. The Schmidt number, Sc
9. The average molecular weight, M_m
10. The density, ρ
11. The diffusion coefficient, D
12. The heat transfer coefficient, h_g
13. The mass transfer coefficient, k_g

Rapid calculation of the physical properties of the saturated gas-vapor mixture can be made by preparation of plots of items 2, 4, 6, 9, 10, 11, 7 ($Pr^{2/3}$), 8 ($Sc^{2/3}$), and 11 versus temperature.

Further improvement can be obtained by combining most of the physical gas-vapor properties in a single factor F, and the heat and mass transfer coefficients in a single coefficient, h_t.

The total heat transfer coefficient for the gas-film, h_t, can be written,

$$h_t = h_g \cdot \left(1 + \frac{k_g \Delta p \lambda_c}{h_g \Delta t}\right) \qquad (13)$$

By substitution of the equations (2) and (3) in Equation (13),

$$h_t = h_g \cdot \left(1 + \frac{M_v \lambda_c}{M_m c p_{gf}} \cdot \frac{Pr^{2/3}}{Sc^{2/3}} \cdot \frac{\Delta p}{\Delta t}\right) \qquad (14)$$

In Equation (14) we can replace λ_c by λ_g, which is accurate enough for most engineering calculations. Introduction of the factor F, where,

$$F = \frac{M_v \lambda_g}{M_m c} \cdot \frac{Pr^{2/3}}{Sc^{2/3}} \qquad (15)$$

delivers,

$$h_t = h_g\left(1 + \frac{F}{p_{gf}} \cdot \frac{\Delta p}{\Delta t}\right) \qquad (16)$$

At this point no account has been made for the sensible heat transferred by the diffusing vapors. When an appreciable amount of the total heat is transferred in this way, the heat transfer coefficient, h_g, may be replaced by an apparent heat transfer coefficient, h_{gi}. This corresponds to the actual heat transferred at the gas-liquid interface.

Recently the author[10] has pointed out that the relation between h_g and h_{gi} can be expressed by the following equation, which is based on the work of Ackermann,[19]

$$h_{gi} = h_g \cdot \frac{\varepsilon}{e^{\varepsilon} - 1} \qquad (17)$$

or,

$$h_{gi} = h_g \cdot \frac{a e^a}{e^a - 1} \qquad (18)$$

where,

$$a = -\varepsilon = \frac{c_v M_v}{c M_m} \cdot \left(\frac{c \rho D}{k}\right)^{2/3} \cdot \ln \frac{P - p_v}{P - p_s} \qquad (19)$$

or,

$$a = \frac{c_v M_v}{c M_m} \cdot \left(\frac{c \rho D}{k}\right)^{2/3} \cdot \frac{\Delta p}{p_{gf}} \qquad (20)$$

Instead of Equation (13), we can now derive,

$$h_t = h_g \cdot \frac{a e^a}{e^a - 1} + \frac{k_g \Delta p \lambda_c}{\Delta t} \qquad (21)$$

or,

$$h_t = h_g\left(\frac{a e^a}{e^a - 1} + \frac{k_g \Delta p \lambda_c}{h_g \Delta t}\right) \qquad (22)$$

And instead of Equation (16), we get,

$$h_t = h_g\left(\frac{a e^a}{(e^a - 1)} + \frac{F}{p_{gf}} \cdot \frac{\Delta p}{\Delta t}\right) \qquad (23)$$

In many tubular cooler-condensers, the correction for the sensible heat transferred by the diffusing vapors can be neglected. This is good, because the evaluation of the factor a involves trial and error work, since the factor a depends on the logarithmic mean partial pressure of the inert gases in the gas film, p_{gf}, see Equation (20).

In Equation (15), the group $(M_v \lambda_g / M_m c)$ for saturated gas-vapor mixtures is a function of the temperature only. In the Prandtl number, $c \mu_f / k_f$, the viscosity and the thermal conductivity should be based on the average film conditions, while the specific heat is to be based on the conditions as found in the main gas-vapor stream, as has been pointed out by Prandtl.[11] In the Schmidt number, $\mu_f / \rho D_f$, both the viscosity and the diffusion coefficient should be based on the average film conditions, while the density of the gas-vapor mixture should be taken as that of the main stream, as can be seen from Colburn's derivation.[12] The quotient of the Prandtl and the Schmidt numbers, $c \rho D_f / k_f$, is thus partly dependent on film conditions. As an approximation we can assume that D/k is proportional with the absolute temperature. Thus, we can write,

$$\frac{D_f}{k_f} = \frac{D}{k} \cdot \frac{T_f}{T_g} \qquad (24)$$

and

$$\left(\left(\frac{c \rho D}{k}\right)_g \cdot \frac{T_f}{T_g}\right)^{2/3} = \left(\frac{c \rho D_f}{k_f}\right)^{2/3} \qquad (25)$$

The group $(T_f / T_g)^{2/3}$ is near to unity in most cooler-condensers. For example, when the temperature of the saturated gas is 203 F., and the temperature of the gas-condensate interface is 131 F., the average film temperature is 167 F., and the factor $(T_f / T_g)^{2/3}$ is equal to $(627/663)^{2/3} = 0.965$. The group $(T_f / T_g)^{2/3}$ can thus be neglected for most engineering calculations, except when very high temperature differentials occur. Thus, we can write,

$$F' = \left(\frac{M_v \lambda}{M_m c}\right)_g \cdot \left(\frac{c \rho D}{k}\right)_g^{2/3} \qquad (26)$$

and,

$$h_t = h_g\left(1 + \frac{F'}{p_{gf}} \cdot \frac{\Delta p}{\Delta t}\right) \qquad (27)$$

The factor F′ has the dimension of a temperature differential. Its introduction is convenient, because as the factor is a function of the gas temperature and gas composition only, it can be calculated in advance for saturated gas-vapor mixtures. It is most convenient to plot F′ against the temperature, and use the plot for the design of cooler-condensers.

Design Procedure—By substitution of Equation (27) in Equation (1), we arrive at the simplified design equation,

$$h_o (t_c - t_w) = h_t (t_g - t_c) = U (t_g - t_w) \qquad (28)$$

or,

$$h_o (t_c - t_w) = h_g \left(\Delta t + \frac{F'}{p_{gf}} \cdot \Delta p\right) = U (t_g - t_w) \qquad (29)$$

This equation must be solved by trial-and-error calculations for several intermediate points in the cooler-con-

denser. It will be evident however, that Equation (29) no longer contains the mass transfer coefficient. If a plot of F′ vs. temperature has been prepared, all that is required is the point to point calculation of the Reynolds number, the gas mass velocity, G, and the heat-transfer coefficient, h_g. A plot of the viscosity of the gas-vapor mixture (saturated) against the temperature helps in calculating the Reynolds number. For calculation of the gas mass velocity use a plot of the absolute humidity, H, against temperature. By eliminating the mass transfer coefficient from the design equation, the point to point computation of the Schmidt number, the average molecular weight, the gas density, and the heat of condensation need not be done. All of these factors are incorporated in the factor *F′*.

The relation between the gas temperature, t_g, and the cooling water temperature, t_w, can be obtained from a simple heat balance, assuming adiabatic conditions in the cooler-condenser.

When several intermediate points in the cooler-condenser have been calculated, the tube area required can be calculated by a graphical integration of Equation (5). The design procedure is similar to the Colburn-Hougen method except for the simplified design Equation (29). The method will be demonstrated in an example of an cooler-condenser handling a saturated mixture of carbon dioxide and water vapor.

The trial-and-error calculations can be shortened by using a graphical procedure in a temperature-vapor pressure diagram, in which the relation between t_c and p_c, as well as t_g and p_g, is represented by the saturated curve.

Graphical Solution—Equation (29) can also be written,

$$h_o (t_c - t_w) - h_g (t_g - t_c) = h_g F' (p_v - p_c)/p_{gf} \quad (30)$$

or,

$$\frac{h_o}{h_g} \cdot (t_c - t_w) - t_g + t_c = F' (p_v - p_c)/p_{gf} \quad (31)$$

When we introduce

$$R = 1/R_h = h_o/h_g, \quad (32)$$

$$(R + 1)\, t_c - R t_w - t_g = F' (p_v - p_c)/p_{gf} \quad (33)$$

Introducing the temperature

$$t_B = \frac{R\, t_w + t_g}{R + 1} \quad (34)$$

delivers,

$$(R + 1)\, (t_c - t_B) = F' (p_v - p_c)/p_{gf} \quad (35)$$

or,

$$\frac{(p_v - p_c)}{(t_c - t_B)} = \frac{(R + 1)\, p_{gf}}{F'} \quad (36)$$

It can be seen that the Equations (7) and (34) for t_B are identical.

Figure 1 is a temperature-vapor pressure diagram with the following points—A (t_w, p_v); E (t_g, p_v); B (t_B, p_v). From Equation (36), a straight line drawn through point B, having a slope of minus $(R + 1)\, p_{gf}/F'$, intersects the saturation curve at point, t_c, p_c, which is the condition of the gas-liquid interface.

When the value of p_{gf} is near to unity or constant, this graphical method is straight forward and requires no trial and error computations. When the value of p_{gf} is unknown, a first trial should be made with a value for p_{gf} which is smaller than $(P - p_w)$, but greater than $(P - p_v)$. Then, by application of the graphical procedure described values for t_c and p_c are obtained, and a corrected value can be calculated for p_{gf}.

If the values so obtained do not satisfy Equation (29), another line with a slope corrected for p_{gf} [See Equation (36)] must be drawn, and the procedure repeated. Usually, one or two trials will give the correct answer, and the graphical solution of the design equation is faster than the normal trial and error calculations. In the following example, all trial-and-error work could be avoided.

Example—This example is from a series of design calculations for a cooler-condenser handling carbon dioxide saturated with water vapor.

Design Conditions—	Shell Side	Tube Side
Fluid flowing	CO_2 (water saturated)	Process Fluid (Water)
Quantity, Pounds per hour	7750 (dry)	254,500
Temperature F In	203	77
Temperature F Out	95	149
Pressure—Atmospheres	1	....
Velocity, feet per second, Max.	....	2
Fouling Factor	0.002	0.0667
	Countercurrent flow	

The heat of condensation is to be recovered by heating the process fluid. The cooler-condenser is to be made of stainless steel. The process fluid is corrosive and the maximum velocity inside the tubes is two feet per second. The saturated carbon dioxide will flow countercurrent with the cooling liquid outside of the tube bundle.

The design conditions for this cooler-condenser are not necessarily the most economical or the most desirable. The particular conditions have been chosen from the series only to show the application of the simplified design method. The result of the calculations will be compared with the result obtained by application of the approximation method recently proposed by Cairns.[8]

Solution:

a. Tube bundle and shell.

Table I shows values of the enthalpy of the saturated carbon-dioxide-water vapor mixture, i, at several intermediate points in the cooler-condenser. All values for the enthalpy are based on the average specific heats for carbon dioxide, $c_p = 0.21$, and for water vapor, $c_p = 0.48$.

The total heat transferred per pound of dry gas is $2407.23 - 39.71 = 2367.52$ Btu-pound. Thus, the amount of cooling liquid is $7750 \times 2367.52/72 = 254{,}500$ pounds per hour.

To keep the liquid velocity in the tubes below the

value specified, 169 stainless steel tubes will be provided, 1.05 inch O.D., 0.824 inch I.D. The liquid velocity is then,

$$\frac{254{,}500 \times 144 \times 4}{169 \times \pi \times 0.824 \times 0.824 \times 63.5 \times 3600} = 1.78 \text{ feet per second.}$$

When the tubes are arranged in a hexagonal bundle, with a pitch 1.5 times the outer diameter of the tubes, an inside shell diameter of 27-inches will be adequate. The maximum free distance perpendicular to the tube bundle is then $27 - (15 \times 1.05) = 11.25$ inches. A baffle distance of 1 foot and 10.5 inches gives a maximum free area for gas flow at the shell side is equal to

$$\frac{1.875 \times 11.25}{12} = 1.755 \text{ square feet.}$$

The total cross section of the tubes is

$$\frac{169 \times \pi \times 0.824^2}{4 \times 144} = 0.626 \text{ square foot}$$

b. Heat transfer coefficients.

The individual heat transfer coefficient for the liquid side can be calculated by using the equation and graph proposed by the Tubular Exchanger Manufacturers Association,[13] or

$$h_w = \frac{16.1}{d}\left[B_t \, k \left(\frac{c\mu}{k}\right)^{1/3} \cdot \phi_t \cdot L_c \right]$$

The viscosity correction factor, ϕ_t, and the length correction factor, L_c, can be taken as unity in this case. The physical properties of the cooling liquid, water, at the average liquid temperature, 113 F., are

$k = 0.368$ Btu/hr. ft. F.
$c = 1.0$ Btu/lb. F.
$\mu = 0.63$ centipoise.

$$\frac{c\mu}{k} = 4.14, \left(\frac{c\mu}{k}\right)^{1/3} = 1.604$$

The mass velocity of the liquid is equal to $\frac{254{,}500}{0.626} =$ 406,500 lb./hr. sq. ft. The Reynolds number, Re, can then be calculated, or

$$Re = \frac{0.824 \times 406{,}500}{12 \times 0.63 \times 2.42} = 18{,}300$$

From Reference 13, Figure T-6, it follows that at Re = 18,300, B_t = 67.0.

Thus,

$$h_w = \frac{16.1}{1.05}[67 \times 0.368 \times 1.604] = 606 \text{ Btu/hr. sq. ft. F.}$$

This coefficient is based on the outside surface of the tubes.

The tube wall is 0.113 inch thick, and the thermal conductivity of the stainless steel is 9.45 Btu/hr. ft. F.

The resistance to heat transfer through the layer of condensate will vary in the condenser. Point-to-point values for this resistance can be calculated by Nusselts condensation equations.[14] The resistance in the condensate layer is a small fraction of the total resistance. Therefore, an average value is usually preferred in the calculation of cooler-condensers. For this case, we will assume that the resistance to heat transfer of the condensate layer is equal to 0.000667 or $h_c = 1500$ Btu/hr. sq. ft. F.

The combined heat transfer coefficient for the liquid side, including the tube wall, the condensate layer, and the fouling factors, h_o, can then be calculated by application of equation (4), or,

$$h_o = \frac{1}{\frac{1}{606} + \frac{0.113 \times 1.05}{9.45 \times 12 \times 0.937} + \frac{1}{1500} + \frac{0.00667 \times 1.05}{0.824} + 0.002} = 71.8 \text{ Btu/hr. sq. ft. F.}$$

This coefficient is considered as constant for the calculation of the cooler-condenser.

The gas side heat and mass transfer coefficients, h_g, and k_g, can be obtained by application of the equations (2) and (3). The gas mass velocity, G, can be calculated from point to point from,

$$G = \frac{7750 \times (1 + H)}{1.79}$$

Values of the humidity, H, have been listed in Table 1.

In Table 2, the specific heat, c, the viscosity, μ, the

TABLE 1
Some Properties of a Saturated Mixture of Carbon Dioxide and Water Vapor

t_g °F.	p_T Atm.	H lb/lb	i Btu/lb	M_m lb / lb.mol.	λ_m Btu/lb
203.0	0.8341	2.0565	2407.23	22.31	976.0
202.1	0.8190	1.8505	2168.62	22.71	976.5
201.2	0.8038	1.6762	1966.84	23.00	977.0
199.4	0.7745	1.4048	1652.60	23.86	979.0
197.6	0.7460	1.2018	1417.39	24.60	980.0
194.0	0.6918	0.9183	1088.87	26.01	983.0
190.4	0.6409	0.7302	870.80	27.33	986.0
185.0	0.5705	0.5435	654.09	29.17	990.0
167.0	0.3804	0.2512	313.60	34.11	1004.0
149.0	0.2468	0.1340	175.63	37.58	1020.0
131.0	0.1553	0.0752	104.93	39.96	1030.0
113.0	0.0946	0.0427	64.44	41.54	1039.0
95.0	0.0555	0.0240	39.70	42.56	1043.0

TABLE 2
Calculation of $Pr^{2/3}$ and $Sc^{2/3}$

t_g °F.	c Btu / lb. °F.	μ lb / hr.ft.	k Btu / hr.ft. °F.	$\left(\frac{c\mu}{k}\right)^{2/3}$	ρ lb/cu.ft.	D ft²/hr	$\left(\frac{\mu}{\rho D}\right)^{2/3}$
203.0	0.392	0.0334	0.01225	1.047	0.0461	0.9425	0.839
202.1	0.386	0.03355	0.01225	1.038	0.0470	0.940	0.831
201.2	0.381	0.03365	0.0122	1.034	0.0477	0.9375	0.826
199.4	0.368	0.0340	0.0121	1.022	0.0496	0.932	0.815
197.6	0.357	0.0345	0.01205	1.011	0.0513	0.927	0.805
194.0	0.339	0.0348	0.0119	0.994	0.0545	0.917	0.785
190.4	0.324	0.0353	0.01175	0.981	0.0575	0.9065	0.770
185.0	0.305	0.0359	0.01155	0.965	0.0620	0.8915	0.750
167.0	0.264	0.03725	0.0110	0.930	0.0745	0.842	0.707
149.0	0.2415	0.03785	0.0105	0.913	0.0845	0.7935	0.683
131.0	0.2285	0.03775	0.0100	0.907	0.0926	0.7465	0.669
131.0	0.2205	0.0373	0.00960	0.903	0.0995	0.701	0.660
95.0	0.216	0.0366	0.00920	0.904	0.1050	0.6565	0.655

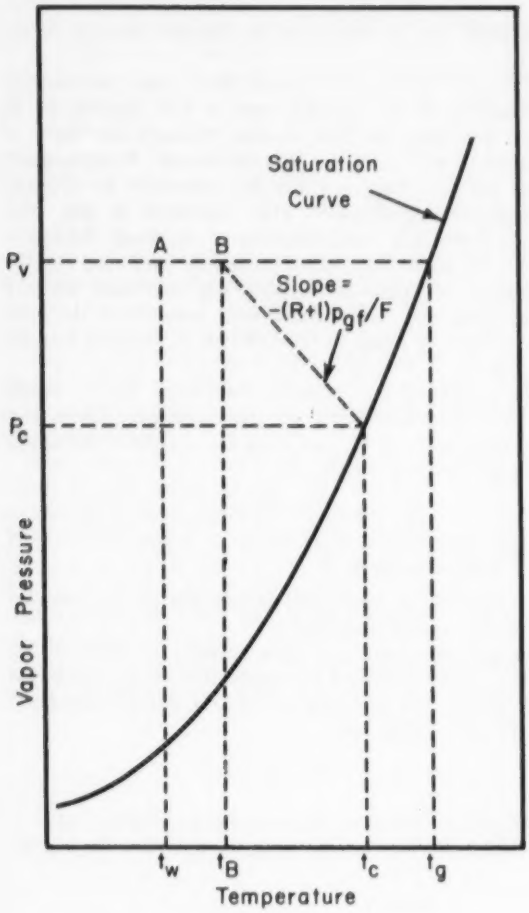

FIGURE 1—Graphical determination of interface conditions from a simple vapor pressure-temperature diagram.

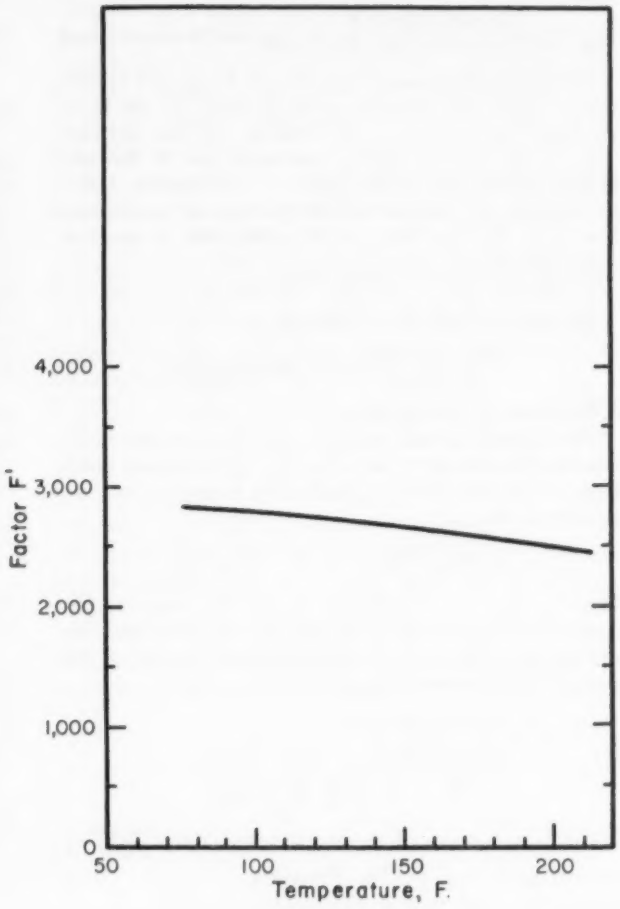

FIGURE 2—Determine the factor F' for saturated carbon dioxide water mixtures.

thermal conductivity, k, the density, ρ, the diffusion coefficient and the 2/3 power of the Prandtl and Schmidt numbers, $Pr^{2/3}$, and $Sc^{2/3}$, are given at several temperatures.

The thermal conductivity, k, and the viscosity, μ, of the mixture have been calculated as the sum of the products of the respective thermal conductivity and viscosity of each component and the mole fraction. This method envolves some error. Since the molecular weights of these two components are not too far different, it is accurate enough for most engineering calculations.

The diffusion coefficient, D, has been calculated from an equation recommended by Arnold,[15] or,

$$D = D_o \cdot \frac{T^{3/2}}{(T + C)} \cdot \frac{657}{273^{3/2}}$$

In this equation, $D_o = 0.5113$ square foot per hour, and T is in degrees Kelvin, and C = 384.

Table 3 shows the calculated Reynolds' number, $Re = d\,G/\mu$ and the heat transfer factor, j, as obtained from Reference 18, Figure 2. Table 3 also gives the point-to-point values of the heat transfer coefficient, h_g, calculated from Equation (2), and values for the factor, F', calculated from Equation (26), or Figure 2.

Table 4 gives the calculated cooling liquid temperatures at several intermediate points in the cooler-condenser. These cooling liquid temperatures, t_w, are easily calculated by assuming adiabatic conditions, and applying the equation for the heat balance, $G_o\,di = L dt_w$, after integration. In the present calculations the heat of the condensate has been neglected.

The reference temperature, t_B, can then be calculated by Equation (7) or (34), see Table 4. In the same table, values of $R = h_o/h_g$ have been given, as well as the negative slope of the tie lines, $(R + 1)(P - p_v)/F'$. Actually, the slope of the tie lines in the temperature-vapor pressure diagram should be calculated with the logarithmic mean temperature of the non-condensing gas, p_{gf}, instead of with $(P - p_v)$, see Equation (36). How-

ever, as the logarithmic mean pressure of the non-condensing gas, p_{gf}, can not be calculated in advance, the first trial will be made with the approximate value of the tie lines as shown in Table 4. The tie lines are straight lines through the points 1-13, $t = t_B$, $p = p_v$. The intersection of these lines with the saturated curve in Figure 3 gives the conditions at the gas-condensate interface, $t = t_c$, $p = p_c$, as indicated by Equation (36). The values of t_c and p_c found in Figure 3 are listed in Table 4.

Next check if the interface conditions obtained with the approximate slope of the tie lines satisfy Equation (29). This is shown in Table 5, where values of $h_o (t_c - t_w)$, and $h_g \left(1 + \frac{F' \Delta p}{p_{gf} \Delta t}\right) (\Delta t)$ are given, as well as the percent deviation with the true $U\Delta t_{ov}$ values. The agreement is surprisingly good, and within the normal accuracy required for engineering computations. In other cases the deviation may be greater. Then, for each point a second straight line through point $t = t_B$, $p = p_v$, should be drawn with a slope equal to minus $(R + 1)\, p_{gf}/F'$. In most cases this second computation will deliver the correct interface conditions, so that Equation (29) can be satisfied.

From Figure 3 notice that the slope of the saturated curve is rather steep over the greatest part of the range in which the cooler-condenser operates. This means that a change in the water vapor pressure, p_c, causes a relatively small change in the water temperature, t_c. Therefore, the heat flux expressed as $h_o (t_c - t_w)$ in Table 5 will be more reliable than the heat flux expressed as $h_g \left(1 + \frac{F' \Delta p}{p_{gf} \Delta t}\right) \Delta t$. This is confirmed by a comparison of these heat fluxes with the true value of $U\Delta t_{ov}$, as obtained by more computations or trial and error calculations. This value is shown in Table 5 as well, and it can be seen that this value for $U\Delta t_{ov}$, and $h_o (t_c - t_w)$ are nearly identical, and the deviations are probably within the accuracy of the graphical method employed.

d. Tube Area

The tube area required can now be calculated by a graphical integration of Equation (5). This is done by plotting values of the amount of heat transferred, q, or of the total heat, i, against $10^4/(U\Delta t_{ov})$, see Figure 4. The curve in Figure 4 represents $\frac{10^4}{U\Delta t_{ov}} = \frac{10^4}{h_o (t_c - t_w)}$ as calculated by the graphical procedure without trial and error computations. The area under the integration curve is equal to $A/G_o = 0.5196$. The area can be measured or found by calculation, e.g. by multiplying

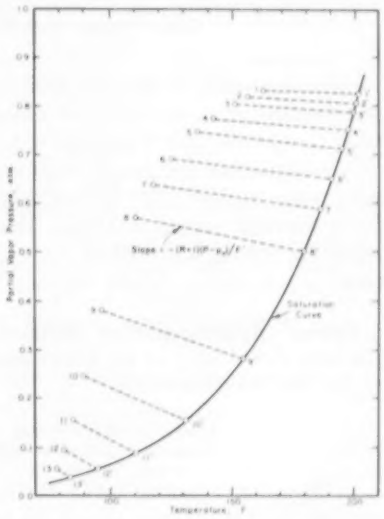

FIGURE 3—Graphical determination of interface conditions for carbon dioxide cooler-condenser.

TABLE 3
Calculation of Heat Transfer Coefficient and Factor F'

t_g °F.	G lb/hr.sq.ft.	Re	j	h_g Btu/hr.sq.ft.°F.	F'
203.0	13,500	35,300	0.0050	25.30	2,506
202.1	12,570	32,800	0.00515	24.10	2,510
201.2	11,810	30,600	0.0053	23.05	2,515
199.4	10,600	27,200	0.00555	21.20	2,516
197.6	9,740	24,800	0.0058	19.95	2,517
194.0	8,460	21,200	0.0062	17.90	2,538
190.4	7,650	18,900	0.0065	16.40	2,553
185.0	6,820	16,600	0.00685	14.75	2,569
167.0	5,515	12,920	0.0076	11.89	2,619
149.0	5,000	11,550	0.0080	10.60	2,669
131.0	4,745	10,960	0.0083	9.91	2,718
113.0	4,605	10,800	0.0084	9.46	2,767
95.0	4,520	10,800	0.0084	9.08	2,803

TABLE 4
Graphical Determination of Interface Conditions

t_g °F.	t_w °F.	t_B °F.	R	$\frac{(R+1)(1-p_v)}{F'}$ atm./°F.	t_c °F.	p_c atm.	p_{gf} atm.	Point Nr. See Fig. 3
203.0	149.0	163.1	2.84	0.000254	202.45	0.824	0.171	1
202.1	141.75	156.9	2.98	0.0002865	201.2	0.806	0.1875	2
201.2	135.6	151.5	3.12	0.0003322	200.1	0.788	0.204	3
199.4	126.05	142.75	3.39	0.000393	197.95	0.7525	0.237	4
197.6	118.9	136.05	3.60	0.000465	195.6	0.718	0.2685	5
194.0	108.9	125.85	4.01	0.000609	191.1	0.6512	0.329	6
190.4	102.25	118.65	4.375	0.000755	186.6	0.5895	0.384	7
185.0	95.7	110.9	4.86	0.000957	179.6	0.5025	0.4635	8
167.0	85.35	96.95	6.04	0.001660	154.95	0.283	0.669	9
149.0	81.15	89.85	6.775	0.00219	131.2	0.1555	0.799	10
131.0	79.0	85.3	7.24	0.00256	111.0	0.0890	0.878	11
113.0	77.75	81.85	7.59	0.00281	95.55	0.0556	0.926	12
95.0	77.0	79.05	7.90	0.00302	84.45	0.0400	0.953	13

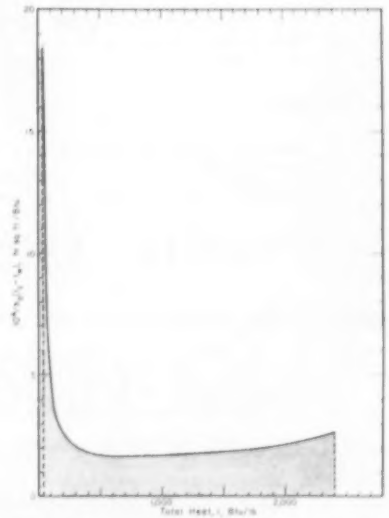

FIGURE 4—Graphical integration curve for the tube surface required in the carbon dioxide cooler-condenser.

TABLE 5
Heat Flux, as Calculated by Various Methods

t_g °F.	$U\Delta t_{ov}$ Colburn and Hougen[5]	$U\Delta t_{ov}$ Graphical Method: $h_o(t_g-t_w)$	% Dev.	$h_g\left(1+\frac{F'\Delta p}{p_{gf}\Delta t}\right)\Delta t$	% Dev.	$U\Delta t_{ov}$: Cairns[8] Method	% Dev.
203.0	3,830	3,835	+0.1	3,755	−2.0	3,830	.....
202.1	4,270	4,260	−0.2	4,150	−2.8	4,790	+12.2
201.2	4,640	4,625	−0.3	4,520	−2.6	5,380	+16.0
199.4	5,150	5,155	+0.1	4,985	−3.2	5,880	+14.2
197.6	5,510	5,500	−0.2	5,275	−4.3	5,925	+ 7.5
194.0	5,895	5,900	+0.1	5,655	−4.1	5,515	− 6.4
190.4	6,025	6,050	+0.4	5,660	−6.1	4,940	−18.0
185.0	5,975	6,015	+0.7	5,640	−5.6	4,130	−30.9
167.0	4,925	5,000	+1.5	4,675	−5.1	2,370	−51.9
149.0	3,540	3,590	+1.4	3,425	−3.3	1,490	−58.0
131.0	2,275	2,295	+0.9	2,235	−1.8	1,005	−55.8
113.0	1,263	1,278	+1.2	1,257	−0.5	725	−42.6
95.0	523	535	+2.3	510	−2.5	523	.....

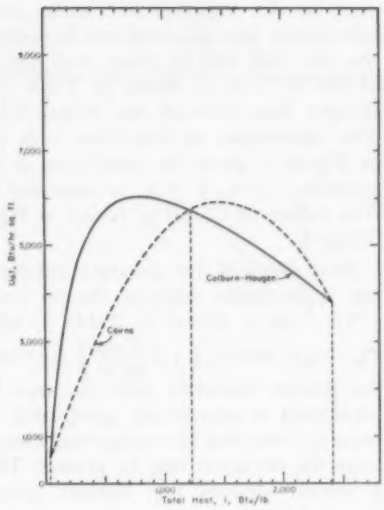

FIGURE 5—Plot of heat flux vs. total heat for the carbon dioxide cooler-condenser showing simplified method compared to Cairns and Colburn-Hougen methods.

incremental values of the total heat transferred, Δi, with the average value of $1/U\Delta t_{ov}$. The latter method has been used in this case. The result is A = 4027 square feet as calculated for the graphical procedure without trial and error, against 4048 square feet as calculated by using the true values of $U\Delta t_{ov}$. The error involved in using the graphical procedure is only 0.5 percent in this case.

Cairns' Approximation Method—From Table 5, the heat flux, $U\Delta t_{ov}$, at the gas entrance and outlet side of the cooler-condenser are:

$$U\Delta t_1 = 3830 \text{ Btu/hr. sq. ft.}$$
$$U\Delta t_2 = 523 \text{ Btu/hr. sq. ft.}$$

In Figure 5, $U\Delta t_{ov}$ as found by the Colburn-Hougen method, has been plotted against the enthalpy. From this graph we find the value for $U\Delta t_{mid} = 5750$ Btu/hr. sq. ft. The constants a, b, and c, can now be calculated from

$$a = 2(U\Delta t_2 + U\Delta t_1 - 2U\Delta t_{mid})/q^2$$
$$b = (U\Delta t_1 - U\Delta t_2)/q$$
$$c = U\Delta t_{mid}$$

In this case,

$$a = -0.00255$$
$$b = 1.3968$$
$$c = 5750$$

$$\text{Then, } A = \int_{-q/2}^{+q/2} dA = \int_{-q/2}^{+q/2} \frac{G_o\, dq}{aq^2 + bq + c}$$

When $b^2 > 4ac$, integration of this equation delivers,

$$A = \frac{G_o}{\sqrt{b^2 - 4ac}}\left[\ln\left(\frac{aq + b - \sqrt{b^2 - 4ac}}{aq + b + \sqrt{b^2 - 4ac}}\right)\right]_{-q}^{+q}$$

In this case we obtain, for + q = 2367.53 Btu/lb.,

$$A = 7750 \times 0.664 = 5146 \text{ square feet}$$

This result is 1098 square feet over the area calculated by the Colburn-Hougen method, or +27.1 percent.

Carey and Williamson Method—As Cairns[8] has pointed out, the graph published by Carey and Williamson[9] can be used instead of the above analytical solution. Then,

$$\frac{U\Delta t_{mid}}{U\Delta t_1} = 1.50$$

$$\frac{U\Delta t_{mid}}{U\Delta t_2} = 11.00$$

From Reference 9, Figure 8, it follows: f = 0.623. Thus, $(U\Delta t)_{av} = 0.623 \times 5750 = 3580$ Btu/hr. sq. ft. and,

$$A = \frac{7750 \times 2367.53}{3580} = 5125 \text{ square feet}$$

This result is about +26.6 percent and confirms the area calculated by Cairns' approximation method.

In Table 5, values for $U\Delta t = aq^2 + bq + c$ (Cairns) for values between +q/2 and −q/2 are given, and the data have been plotted in Figure 5 against the enthalpy. There are considerable deviations between the two curves in Figure 5. The main reason for these deviations is that Cairns' equation, $U\Delta t = aq^2 + bq + c$, calls for a parabola with the main axis parallel to the $U\Delta t$ abscissa. Actually, the true curve as shown in Figure 5 does not closely approach such a parabola. The deviations of the heat flux at intermediate points as calculated by Cairns' equation, vary between +16 percent, and −58 percent, see Table 5.

In another example calculated by Kern[16] the application of Cairns' approximation method showed an error of −42 percent, and the curve of the heat flux, $U\Delta t$, against the total heat transferred, Q, showed an inflection.[8]

The design calculations for a scrubber-condenser handling a saturated mixture of carbon dioxide and water vapor will be published elsewhere.[17] In this case the application of Cairns' approximation method gave an error of about −27 percent.

The approximation methods proposed so far may involve considerable error. The simplified method presented here will be helpful when a more accurate result is required. Use of the proposed graphical computation of

the interface conditions should speed up the design calculations of cooler-condensers.

More intermediate points have been calculated in the example than would normally be required for this type of engineering calculation. This was done to have a better basis of comparison with the approximation method proposed by Cairns.[8]

Examination of the tables will show that some of the physical properties of the gas-vapor mixture do not vary greatly with temperature, e.g., $Pr^{2/3}$, $Sc^{2/3}$. Calculating these properties for a few points and determining intermediate points from a plot of these physical properties against temperature can save time. In some cases it may be practical to do the same for heat and mass transfer coefficients, h_g and k_g/p_{gf}. In other cases it will be necessary to calculate values for these transfer coefficients for all intermediate points.

Generally, the factor F′ varies little with temperature for many gas-vapor mixtures. Using this factor and eliminating the mass transfer coefficient, k_g, will speed up the calculations. The factor F′ is a function of the physical properties of the gas-vapor mixture only. The mass transfer coefficient, k_g, is a function of the Reynolds number, Re, and the gas mass velocity, G, see Equation (3). To determine the optimum operating conditions for a cooler-condenser of minimum costs a series of design calculations is often made. In making these calculations variations in tube diameter, gas mass velocity, etc., are introduced. Time can be saved by introducing the factor F′ and eliminating the mass transfer coefficient, k_g, from the design equations.

This simplified method can be helpful in speeding up the design calculations without appreciable loss of accuracy, especially when the graphical method described for the calculation of the gas-liquid interface conditions is used.

NOMENCLATURE

A	Cooler-condenser tube area, square feet.
a	$k_g \Delta p\ c_v/h_c$, dimensionless, Equations (17)-(23).
a, b, c	Constants, see Equation (12).
C	Sutherland's constant.
C_m	Heat capacity at constant pressure of gas-vapor mixture, Btu/lb. mol. F.
c, c_v	Heat capacity at constant pressure of gas-vapor mixture, and vapor, respectively, Btu/lb. F.
c_s	Humid heat capacity at constant pressure of gas-vapor mixture, Btu/F. lb. dry gas.
D	Diffusion coefficient, sq. ft./hr.
F, F′	$(L_v/C_m) \cdot (Pr/Sc)^{2/3}$, see Equations (15) and (26).
G	Mass velocity of gas-vapor mixture, lb./hr. sq. ft.
G_n	Flow rate of non-condensing gas, lb./hr.
H	Absolute humidity, lb./lb.
h_c, h_d, h_L, h_w, h_o	Heat transfer coefficients, respectively related to condensed liquid layer, dirt and scale layer, metal tube wall, cooling water, and the total of all these resistances, see Equation (4), Btu/hr. sq. ft. F.
h_g	Heat transfer coefficient of the gas-vapor mixture, Btu/hr. sq. ft. F.
$h_{g'}$	Apparent heat transfer coefficient, corrected for the effect of the sensible heat transferred by the diffusing vapor, Btu/hr. sq. ft. F.
h_t	Total heat transfer coefficient at the gas side, including the latent heat of the diffusing vapor, Btu/hr. sq. ft. F.
i	Enthalpy of gas-vapor mixture, Btu/lb. of vapor free gas.
Δi_m	Logarithmic mean enthalpy difference at entrance and outlet of the cooler-condenser, between the gas-vapor mixture and the saturated gas in equilibrium at the cooling water temperature, Btu/lb. of dry gas.
j_H, j_M, j	Heat- and mass transfer factor, and transfer factor respectively, dimensionless.
k	Heat conductivity of the gas-vapor mixture, Btu/hr. ft. F.
k_g	Gas mass transfer coefficient, lb./hr. sq. ft. atm.
L_v	Latent heat of condensation, Btu/lb. mol.
M_v, M_m	Molecular weight of the vapor, and the gas-vapor mixture, respectively, lb./lb. mol.
m	Slope of the saturation curve in an enthalpy vs. temperature diagram, at the temperature of the cooling water, Btu/lb. dry gas per F.
P	Total pressure, atm.
p_c, p_v	Partial vapor pressure at gas-liquid interface, and at the main stream of the gas-vapor mixture, atm.
Δp	$p_v - p_c$, atm.
p_{gf}	Logarithmic mean pressure of the non-condensing gases in the gas-film, atm.
Pr	Prandtl number, $c\mu/k$, dimensionless.
Q	Total heat transferred in the cooler-condenser, Btu/hr.
q	Total heat transferred in the cooler-condenser, Btu per lb. of dry gas.
R	$1/R_h = h_o/h_g$, dimensionless.
Re	Reynolds' number, dG/μ, dimensionless.
R_h	h_g/h_o, dimensionless.
R_m	$k_g\lambda/h_o$, F./atm.
Sc	Schmidt number, $\mu/\rho D$, dimensionless.
T	Absolute temperature, R.
T_g, T_f	Absolute temperature of the main bulk of the gas-vapor mixture, and average absolute film temperature, respectively, R.
t_c, t_g, t_w	Temperature of the condensed liquid, the gas-vapor mixture, and the cooling water, respectively, F.
t_n	Temperature defined by Equations (7) or (34), F.
Δt	$t_g - t_c$, F.
U	Over-all total heat transfer coefficient, Btu/hr. sq. ft. F.
U_o/c_o	Total gas film heat transfer coefficient, Btu/hr. sq. ft. per unit enthalpy difference.
λ_c, λ_g	Latent heat of condensation at the temperature of the condensate, and of the main bulk of the gas stream, Btu/lb.
ε	$-a = k_g (p_c - p_v)\ c_v/h_c$, dimensionless.
ρ	Density of the gas-vapor mixture, lb./cu. ft.
μ	Viscosity of the gas-vapor mixture, lb./hr. ft.

Indices:

1	Entering gas-vapor mixture.
2	Leaving gas-vapor mixture.
c	Condensate.
f	Gas film.
g	Main bulk of gas-vapor stream.
m	Average.
w	Cooling water.

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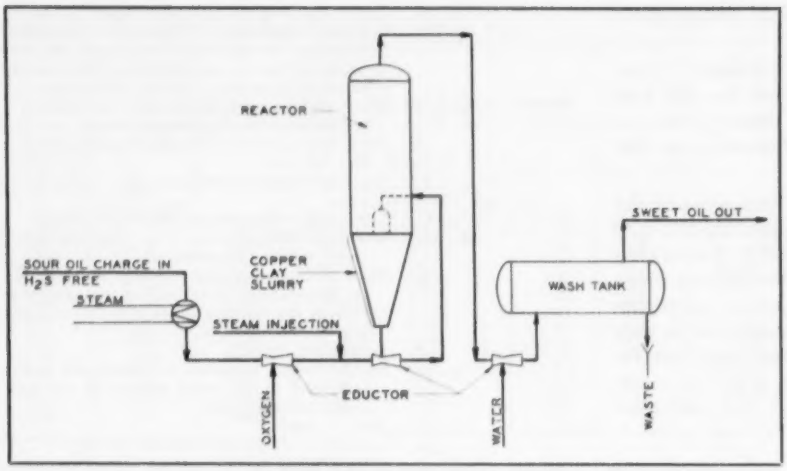


Copper Sweetening Process Flow.

Control the Slurry In Copper Sweetening

C. S. Ramsey
McColl-Frontenac Oil Company, Ltd., Montreal

GASOLINES AND distillates produced from the process units commonly contain mercaptans of the general formula RSH. These mercaptans impart an objectionable odor to products containing them even in very small amounts.

Mercaptans can be rendered odorless by oxidation to disulfides of the general formula RSSR. In the refineries of McColl-Frontenac Oil Company Limited this is accomplished by the copper sweetening process using air or oxygen in the presence of cupric chloride on a clay carrier.

Copper Sweetening—In the sweetening reaction, summarized by the equation

$$2RSH \xrightarrow[CuCl_2]{O} RSSR + H_2O,$$

water is liberated in proportion to the mercaptan content of the raw charge to the reactor. This water tends to be absorbed by the clay carrier, and it is necessary to control the water content of the clay within certain definite limits.

It will be seen from the flow plan that the reactor has a conical clay settling section at the bottom, to collect the clay-copper mixture for feeding into an eductor for recirculation. If the slurry is too dry it will carry over from the reactor to the water wash vessel in excessive amounts, giving unnecessarily high chemical costs. On the other hand, a wet slurry will mud-up and refuse to circulate, and the treated product will go sour, as the mercaptans in the charge pass through the reactor unchanged.

Generally speaking it has been found that the most successful operation is obtained when the water content of the slurry is held between 10 and 15 percent.

Control of Water Content of Slurry

(a) **Normal Conditions**—under normal conditions, the water liberated in the sweetening reaction is slightly in excess of the amount required to hold the moisture content of the slurry at the optimum level. By preheating the charge stock to raise the water solubility in the hydrocarbon stream, water is removed at the same rate as it is produced. In all cases a temperature not less than 80-90 F. in the reactor is required for the reaction to proceed at an adequate rate.

As an example, a charge stock having a copper number (milligrams of mercaptan sulfur per 100 millilitres of oil) around 15, and saturated with water at 90 F., would require about 10 F. preheat to maintain the catalyst water balance.

A charge stock containing a larger amount of mercaptan sulfur would require more preheating to desaturate it enough to absorb the greater amount of water of reaction.

(b) **Winter Conditions**—Certain peculiarities of the operation arise from the low temperatures encountered in the course of Canadian winters.

When a gasoline or distillate cools in tankage to 30 or 40 F. it loses most of its dissolved water. Thus, when heated to 80 or 90 F., as is required for the reaction, the charge enters the reactor with a higher than normal ability to remove water from the slurry. If at the same time the copper number falls below 10 as commonly occurs when processing gasolines from fairly sweet crude oils or when charging No. 1 burner oil from even quite sour crude oils, it will be found impossible to keep the slurry moisture content up to the required level. The charge stock will dry out the slurry if heated to normal reaction temperature and water is produced in too small a quantity to compensate.

When this happens chemical losses increase to the point where the process becomes inoperable.

This particular problem was solved at McColl-Frontenac's Montreal Works by the addition of small amounts of live steam to the charge stock immediately before contact with the slurry.

The addition of steam to the reactants was at first attended by considerable misgivings as it was felt that the free moisture might form hydrochloric acid in contact with the cupric chloride. This would cause corrosion in the reactor. However, regular inspection over a three year period has shown no ill effects from steam addition, and it has therefore been used whenever necessary.

Summary

(a) Control of the copper-clay slurry water balance is essential to operation of the reactor.

(b) Excess moisture is removed by heating the hydrocarbon stream to a degree of water unsaturation in balance with water production.

(c) A very cold charge of low mercaptan content will dehydrate the slurry. This condition is controlled by the addition of small amounts of live steam before the reactor. ##

An easy way to . . .

Design Packed Columns

The nomograph on the following page will facilitate packed tower design. Here is a discussion of the data used to construct it.

John K. Jacobs
United Engineers and Constructors, Inc., Philadelphia

THE DIAMETER, pressure drop, and allowable velocity may be found directly for the design of a packed column when using the accompanying nomograph. It is assumed that the column design is to be based on a loading factor that is 60 percent of that required to flood the dumped packing.

The loading factor is defined as:

$$L.F. = R/\rho_r^{0.5}$$

The data used for constructing the nomograph were taken from Page 40 of the second edition of Max Leva's text on "Tower Packing and Packed Tower Design," published by the U. S. Stoneware Company, Akron, Ohio. Therein a plot presents flooding and loading allowable gas velocity limits versus loading factor as well as a generalized pressure drop correlation. The velocity is presented in the form

$$\frac{G^2\, a\, \psi^2\, \mu^{0.2}}{\rho_g\, \varepsilon^3\, \rho_l\, g}$$

while the pressure drop is indicated as a parameter (in inches of water per foot of packing).

The nomograph covers the normal range of variables. For values outside these ranges, the loading coefficient, C, may be used in the following equations:

$$u = \frac{\rho_g\, \rho_r^{1.5}}{C\, \mu^{0.1}}$$

$$D^2 = \frac{F}{47.1\, u}$$

Usually the loading factor is used to enter the nomograph. Here is an example problem to demonstrate the method of solution.

Example: Use 1-inch Raschig rings
Liquid load = 70,000 pounds per hour
F = 900 cubic feet per minute
ρ_g = 0.15 pound per cubic foot
ρ_l = 45 pounds per cubic foot
By calculation:

$$R = \frac{70{,}000}{(900)\ (0.15)\ (60)} = 8.66$$

$$\rho_r = \frac{45}{1.5} = 300$$

$$L.F. = \frac{8.66}{(300)^{0.5}} = 0.5$$

From the nomograph:
ΔP at flooding = 0.835 psi per foot
ΔP at 60 percent flooding = 0.288 psi per foot
u = 0.8 feet per second
D = 4.9 feet
Therefore use 5-foot diameter packed tower.

SYMBOLS USED

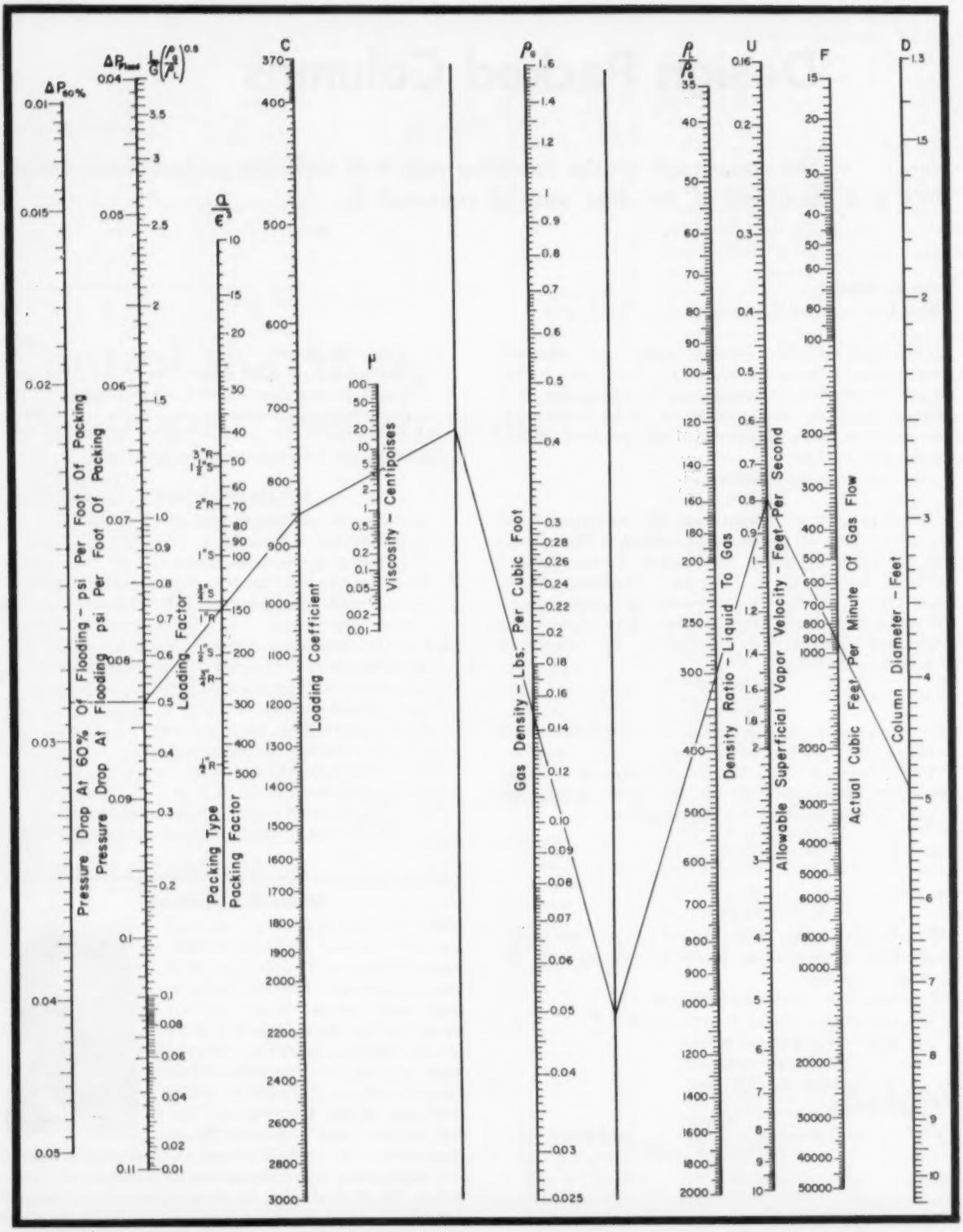
a = Specific packing surface, sq. ft. per cu. ft.
C = Loading coefficient
F = Actual gas flow, cu. ft./min.
G = Gas superficial mass velocity, lb./(hr.) (sq. ft.)
g = Gravitational constant, 4.18 (lb. mass) (ft.)/(lb. force) (hr.^{2})
L.F. = Loading factor, dimensionless
R = Weight ratio of liquid flow to gas flow
u = Superficial gas velocity, ft./sec.
μ = Liquid viscosity, centipoises
ΔP = Pressure drop, psi/ft. packing
ε = Fractional voids, dimensionless
ρ_l = Liquid density, lb./cu. ft.
ρ_g = Gas density, lb./cu. ft.
ρ_r = Ratio, liquid to gas density, dimensionless
ψ = Ratio water density to liquid density, dimensionless. ##

Meet the Author

JOHN K. JACOBS is a process engineer with United Engineers & Constructors, Inc., in Philadelphia. With the company since 1954, his duties include both process design and economic studies. His background in the process industries spans some 18 years with such companies as Electric Furnace Products Company, Allied Chemical & Dye Corporation's Barrett division and Industrial Rayon Corporation. He holds B. S. and M. S. degrees in chemical engineering from Massachusetts Institute of Technology. In Pennsylvania, he is a registered professional engineer.

Nomograph on next page ➧

An Easy Way to Design Packed Columns . . .


Pressure Drop At 60% Of Flooding – psi Per Foot Of Packing
Pressure Drop At Flooding psi Per Foot Of Packing
Loading Factor
Packing Type
Packing Factor
Loading Coefficient
Viscosity – Centipoises
Gas Density – Lbs. Per Cubic Foot
Density Ratio – Liquid To Gas
Allowable Superficial Vapor Velocity – Feet Per Second
Actual Cubic Feet Per Minute Of Gas Flow
Column Diameter – Feet

This nomograph yields pressure drop, vapor velocity and diameter of packed column (R = Raschig rings and S = Intalox saddles).

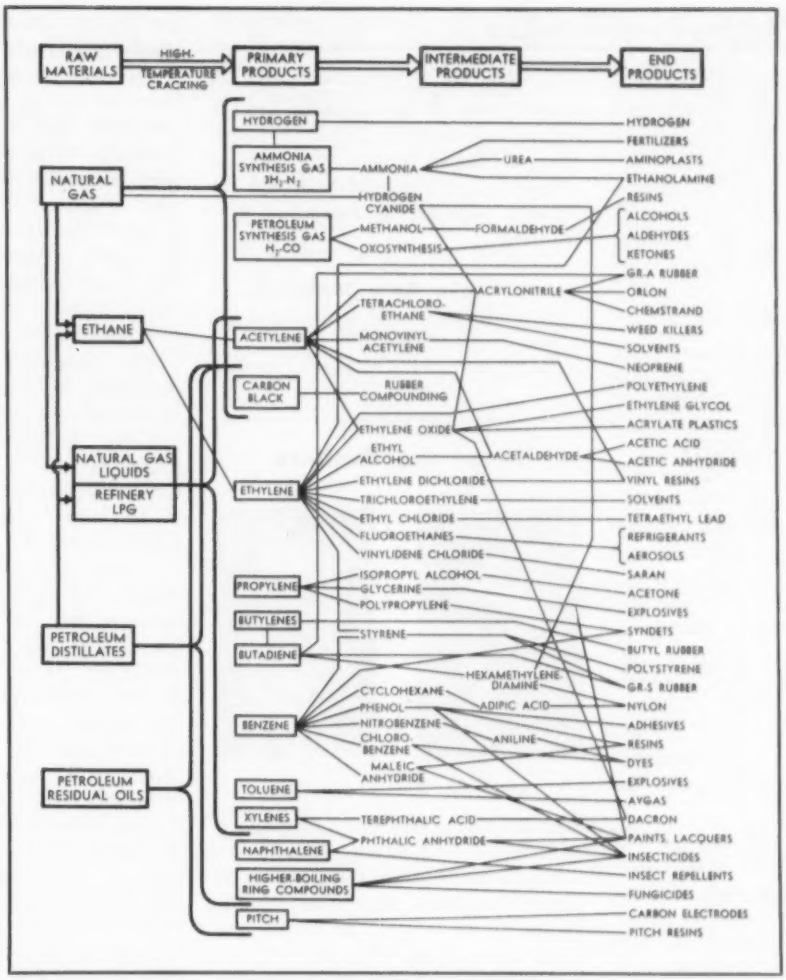


FIGURE 1—These petrochemicals can be produced from natural gas, natural gas liquids, and petroleum.

New Data for Making Petrochemicals

Ethane, Ethylene, Acetylene, Propylene and Butylene can be made from a complete range of petroleum raw materials. These pilot data show how.

H. R. Linden and J. M. Reid
Institute of Gas Technology, Chicago

PETROCHEMICALS are defined as chemical compounds or elements recovered from petroleum or natural gas, or derived in whole or in part from petroleum or natural gas hydrocarbons, and intended for chemical markets.[5] Within the limits of this definition petrochemicals are classified as:

- **Aliphatics**—derived from crude products such as ethane, ethylene, acetylene, propane, propylene, butylene and butadiene.
- **Aromatics**—derived from benzene, toluene, xylene, naphthalene and other unsaturated cyclic hydrocarbons.
- **Inorganics**—ammonia, carbon black, sulfur and hydrogen cyanide.

For conversion of petroleum fractions and natural gas hydrocarbons to crude products such as olefins, diolefins, acetylene, aromatics, carbon black and synthesis gases, processes involving high temperature vapor-phase thermal cracking, high temperature catalytic reforming with

steam, partial combustion, and catalytic aromatization and dehydrogenation are employed. Direct oxidation and halogenation of natural gas hydrocarbons for the production of low-molecular weight alcohols, aldehydes, and low-molecular weight aliphatic halides are also employed to a lesser extent.

In Figure 1, the raw materials required in the production of crude petrochemicals by cracking or reforming of hydrocarbons are related to the intermediate and end products. The most widely used crude aliphatic petrochemical is ethylene. It is a raw material in the production of polyethylene, and intermediates such as ethyl alcohol, ethylene glycol, styrene, and a large number of halogenated derivatives. This group of intermediates plays a major role in the production of synthetic fibers, synthetic rubber, plastics and tetraethyl lead.[7,31] Ethylene production in 1954 was 2.3 billion pounds, and is expected to increase substantially in 1956, in part to satisfy the rapidly increasing demand for polyethylene.[24]

Acetylene is another fast-growing aliphatic petrochemical and represents a more versatile raw material for the manufacture of plastics, fibers, and special purpose synthetic rubbers normally derived from ethylene. It is also the source of neoprene rubber. The current demand for chemical purposes is estimated at over 500 million pounds annually, and a demand of up to two billion pounds has been forecast for 1960.[1] However, at present, most of these requirements are met with carbide acetylene.

Propylene, butylene and butadiene are other crude aliphatics in the billion pounds per year and higher category. Propylene is used in the production of synthetic detergents,[33] glycerine and acetone, while butylene and butadiene are required for butyl and GR-S rubber manufacture.

In 1954 the total production of crude aromatics from petroleum sources was 2.8 billion pounds.[35] This included approximately one-third of the benzene, three-fourths of the toluene, and nearly all of the xylenes produced for chemical use. Although petroleum-derived paraxylene, required in the production of Dacron, gained particular importance, coke oven light oils and tars continue to supply most of the aromatic crudes. While the potential supply of petroleum aromatics is large, the present relatively low price level diverts increasing amounts to motor fuel production.

Available Raw Materials—A very small fraction of the natural gas transmitted and distributed by the gas industry, and of the recovered natural gas liquids, would supply all of the crude products necessary for ammonia and aliphatics chemical production; for example, the ethylene produced from natural gas today is estimated to be only four percent of that potentially recoverable (in the form of ethane). Less than three percent of the total volume of crude petroleum produced in the U. S. goes into petrochemicals, with only 1 percent consumed in the primary products, and 2 percent as fuel.[2,25]

The petrochemical industry has prospered because of the abundant supply of raw materials at relatively low cost in economically attractive locations, and the high value and specialized use of its products. There is, however, concern regarding the rapid increase in the cost of natural gas. Some authorities say that it will become uneconomical to use natural gas as a raw material for the production of low-cost petrochemical products when its price reaches 20 cents per Mcf; however, manufacturers of more costly specialty products could probably pay as much as 40 cents per Mcf.[11,23] At present, there seems to be a definite effort by some petrochemical producers to become less dependent on natural gas as a raw material. For example, approximately half of the carbon black produced in 1955 was derived from oil,[11] and it is expected that the amount made from natural gas will decline rapidly after 1955.[3]

The Texaco Development Corporation-Hydrocarbon Research, Inc. process[8,28] for high-pressure ammonia synthesis gas production from fuel oil in place of natural gas also appears to gain acceptance. It has been reported that for ammonia synthesis, natural gas at 30 cents per Mcf is equivalent to $2.35 per barrel of fuel oil when relative investment and operating costs are considered.[36] Some new plants will be based on this new fuel, and others may convert if natural gas prices continue to rise.

Semet-Solvay Division of Allied Chemical and Dye Corporation is already producing polyethylene from high-purity ethylene obtained by cyclic thermal cracking of residual oils, and also produces benzene, propylene and butadiene by this method. In the long range, because of the abundance of coal in desirable locations, aromatics production by hydrogenation of coal appears to offer

Meet the Authors

Linden

Reid

HENRY R. LINDEN, as research director for the Institute of Gas Technology is responsible for research in the production of natural-gas supplements by conversion of natural-gas liquids, petroleum oils and coal, together with studies of gas processing, transmission, distribution and utilization. With the institute since 1947, he previously was with Socony Mobil Oil Company in its Brooklyn laboratory. Dr. Linden is a graduate of Georgia School of Technology (1944), with a master's degree in chemical engineering from Polytechnic Institute of Brooklyn (1947) and a Ph.D. from Illinois Institute of Technology (1952). He is author of a number of technical articles and holds several patents in natural-gas processing.

JACK M. REID has been the Institute of Gas Technology's supervisor of thermal cracking and oil gasification for the past year. With the institute since 1949, he now is in charge of its research and development of processes for the conversion of hydrocarbons. In the Army, he was assigned to the Engineers' Research and Development laboratories at Fort Belvoir, Va. Reid is a 1949 graduate of the University of Maryland.

many advantages over competing petrochemical processes for supplementing the basic supply from coke-oven operation.

Cyclic thermal cracking processes also have great potentialities for converting low-cost petroleum oils into valuable petrochemicals near their major markets. A single 12-foot OD Hall high-Btu oil gas set[12] operating on residual oil could produce 30 million pounds of ethylene, 30 million pounds of pitch, and 10 million pounds of light aromatics per year, as well as substantial quantities of propylene, butylene and butadiene. The ease of transporting and storing petroleum oils may make this the most economical source of olefins and aromatics. Similarly, high-temperature cyclic thermal cracking processes for the production of acetylene from excess supplies of propane, butane and natural gasoline,[6,10] appear to be competitive in many areas with carbide acetylene or with acetylene produced by partial combustion of natural gas.

At present, continuous high-temperature vapor-phase cracking of ethane and LPG carried out in oil- or gas-fired tube furnaces provides the major portion of ethylene and propylene. The catalytic processes for the production of butenes and butadiene by vapor-phase dehydrogenation of LPG, and for the production of benzene, toluene and xylenes by aromatization of petroleum distillates (platforming, hydroforming, Houdriforming), are responsible for supplying most of the remaining demand of aliphatic and aromatic crude petrochemicals. About one-fourth of the LPG produced in the U. S. is used in chemical, including synthetic rubber, manufacture.

Production of Olefins, Diolefins and Aromatics—It is possible by adjustment of cracking conditions to produce the entire range of olefins, diolefins, acetylenes, light and heavy aromatics, and pitch, in simple thermal cracking operations. The influence of feedstock properties, residence time, cracking temperature, pressure, and dilution with inert and reactive carrier gases, on gaseous and nongaseous product yields and compositions has been studied extensively and is well understood.[16,19-21]

Except for the high molecular weight, condensed-ring naphthenes and aromatics, all hydrocarbons and hydrocarbon mixtures when exposed to temperatures above 1300 F. at moderate pressures crack into the same liquid and gaseous products at equivalent conditions (Figure 2). The mechanism of the vapor-phase reactions forming these products is identical after the primary cracking reactions, that is, those specific to the feed hydrocarbon, have been completed.[19]

The primary reactions involve the breaking of carbon-carbon and carbon-hydrogen bonds to form free radicals consisting of one- and two-carbon atom species. These free radicals, and nascent hydrogen, are the building blocks for the entire range of low-molecular weight, gaseous aliphatic hydrocarbons and the low, intermediate and high molecular weight liquid and solid aromatics.

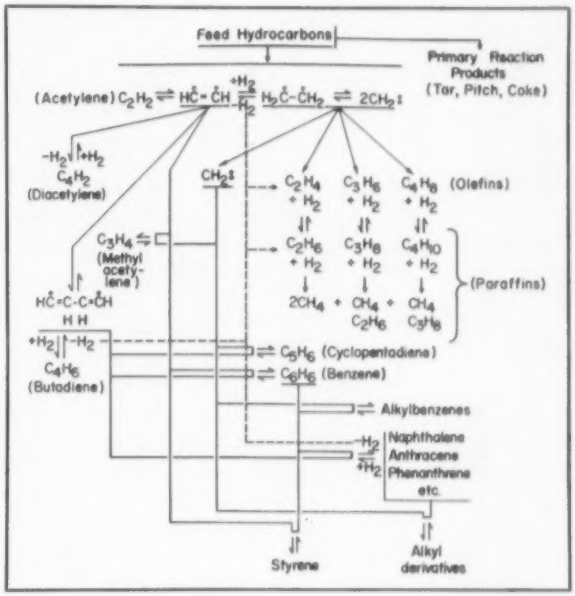


FIGURE 2 — This is the general mechanism of high-temperature vapor-phase cracking of hydrocarbons and the end products made.

The distribution between the relatively high hydrogen content gaseous hydrocarbons and the free hydrogen always associated with them, and the low hydrogen content liquid and solid aromatic hydrocarbons, depends on the carbon/hydrogen ratio of the feed;[20,21] the higher its C/H ratio, the higher the percentage of nongaseous products formed.

The higher molecular weight condensed-ring hydrocarbons do not crack in the vapor phase; they form tar, pitch and coke directly by dehydrogenation, cyclization and polymerization. At very severe cracking conditions, vapor-phase carbon (lampblack) is also formed by dehydrogenation of low molecular weight intermediates.

The formation of olefins and diolefins is favored by short residence times and low pressures or low partial pressures at moderate temperatures (1400-1500 F.), since the intermediates normally forming these unsaturated gaseous products tend to polymerize, condense and dehydrogenate into liquid and solid products. Consequently, commercial operations for olefin and diolefin production are usually conducted at residence times of less than one second in the presence of large amounts of diluent steam and/or low pressure.

The yields of low molecular weight aromatics are highest at intermediate pressures (one to three atmospheres partial pressure) and residence times of five to ten seconds, while the production of higher molecular weight aromatics is favored by higher pressures. The formation of methane is also favored by pressure and increased residence times. Thus, high conversions of a feedstock to methane and nongaseous products mean low conversions to ethylene, propylene and butadiene. The processes for the production of natural gas supplements and substitutes, in which methane and ethane are maximized, employ residence times from one to ten seconds, minimum steam dilution and, where possible, superatmospheric pressure and process hydrogen.[17-19]

The Institute of Gas Technology has conducted extensive studies of

New Data for Making Petrochemicals . . .

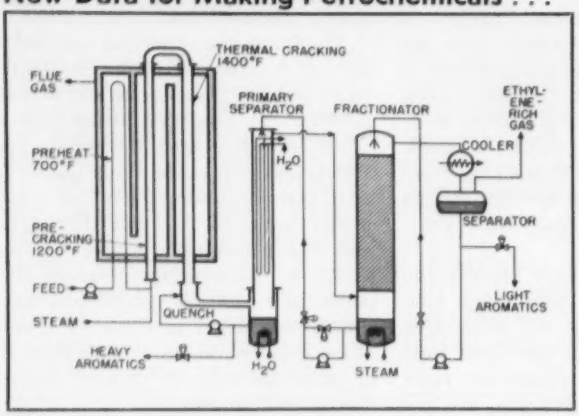


FIGURE 3—High-temperature vapor-phase cracking pilot plant for production of ethylene and aromatics. Notice the use of heavy aromatics for quench liquid at the furnace outlet.

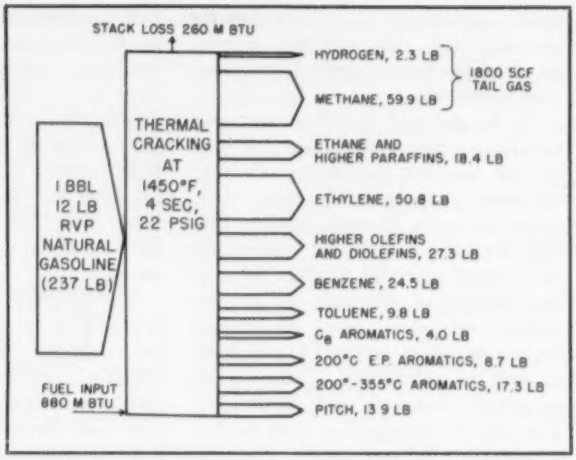

STACK LOSS 260 M BTU
HYDROGEN, 2.3 LB
1800 SCF TAIL GAS
METHANE, 59.9 LB
THERMAL CRACKING AT 1450°F, 4 SEC, 22 PSIG
ETHANE AND HIGHER PARAFFINS, 18.4 LB
1 BBL 12 LB RVP NATURAL GASOLINE (237 LB)
ETHYLENE, 50.8 LB
HIGHER OLEFINS AND DIOLEFINS, 27.3 LB
BENZENE, 24.5 LB
TOLUENE, 9.8 LB
C_8 AROMATICS, 4.0 LB
200°C E.P. AROMATICS, 8.7 LB
200°-355°C AROMATICS, 17.3 LB
FUEL INPUT 880 M BTU
PITCH, 13.9 LB

FIGURE 4—These are the results of thermal cracking, in the pilot tube furnace, one barrel of 12-pound RVP natural gasoline.

thermal cracking of propane, butane and natural gasolines in an electrically-heated 2½-inch ID laboratory tube reactor with a complete liquid products recovery system. It was found possible to control carbon laydown in the absence of steam to a level which permitted semicontinuous operation at tube temperatures of 1400-1500 F, one to ten seconds residence time, and one to three atmospheres total pressure.

Typical results for conversion of natural gas liquids to ethylene and aromatics are given in Table 1. It can be seen that ethylene yields are 25-30 wt percent under conditions which give benzene-toluene-xylene-ethylbenzene-styrene yields of up to 16 wt percent. Considerably higher ethylene yields can be obtained by using diluent steam and shorter residence times.

For comparison, equivalent data obtained from a 24.1° API, 7.04 C/H ratio reduced crude oil are also shown in Table 1. Although such a feedstock could not be cracked in a tube furnace under the conditions required for ethylene and aromatics production, the results are indicative of the product distribution which can be obtained from residual petroleum oils in high-temperature thermal cracking operations.[19, 20, 21]

A larger pilot unit designed primarily for conversion of natural gas liquids to natural gas substitutes was also operated in 1952 and 1953 under conditions suitable for petrochemical production.[17] This pilot plant (Figure 3), constructed and operated under sponsorship of The East Ohio Gas Company, consisted of a gasoline storage system, twin feed systems, an automatically controlled gas- or oil-fired tube furnace, a products-recovery system permitting separate recovery of light and heavy aromatics, and a gas metering and storage system.

The furnace consisted of an upflow radiant section containing two 6-inch OD x 5-inch ID x 25-foot Type 310 stainless steel reactor tubes; a high-temperature, downflow convection section, containing two Schedule 40, 4-inch x 25-foot alloy tubes; and a low-temperature upflow section containing finned tubes for feed vaporization. The reactor tubes were connected to 8-inch x 4-inch right angle offtakes through which byproduct heavy aromatics were circulated at a high rate for product quenching.

The total raw product stream then passed into a water-cooled primary separator for removal of heavy aromatics and pitch, a fractionator for removal of intermediate aromatics (recycled to the primary separator), and condensers for light aromatics recovery (with light aromatics reflux to the fractionator).

Typical results for operation at 22 psig, 1450 F average maximum tube temperature and at 3.8 seconds residence time in the absence of steam are shown in Figure 4. Approximately 20 wt percent ethylene, 8 wt percent ethane, propane and butanes, 12 wt percent higher olefins and diolefins,

TABLE 1—Product Distribution for Thermal Cracking of Hydrocarbon Fuels

FEED	Propane	Butane	12 Lb. RVP Natural Gasoline	Reduced Crude Oil
Operating Conditions:				
Cracking Temperature, F	1500	1400	1400	1470
Total Pressure, atmospheres	1.00	1.02	1.00	1.02
Residence Time, seconds	4.5	10.9	9.6	2.5
Steam-Hydrocarbon Feed Ratio, lb/lb	0	0	0	0.15
Product Distribution, Wt. % of Feed:				
Methane	36.15	28.70	28.28	15.11
Ethane	3.70	6.80	5.18	3.62
Propane	0.42	....	0.78	0.21
Isobutane	....	....	0.20	....
n-Butane	0.28	0.68	....	0.14
Ethylene	28.44	30.11	24.08	17.88
Propylene	1.99	4.92	3.41	5.86
Butenes	0.27	0.44	0.39	1.06
1, 3 Butadiene	1.79	1.48	1.33	2.43
Cyclopentadiene	0.31	0.27	0.24	0.62
Hydrogen	2.26	1.15	1.13	0.79
Acetylene	0.49	0.10	....	0.18
Inerts	1.93	1.42	0.25	0.21
Benzene	7.71	12.57	9.04	
Toluene	1.08	1.91	1.87	
Xylenes	0.38	0.06	....	
Ethylbenzene	0.29	0.29	0.64	
Styrene	0.66	0.71	0.82	10.01
C_8 + Aromatics in 0—200C Distillate	0.96	0.86	1.60	
Olefins in 0—200C Distillate	1.40	0.83	1.12	
Paraffins in 0—200C Distillate	0.10	0.67	1.05	
Distillate 200—300C	3.70	1.48	5.77	8.63
Distillate 300—355C	1.12	0.49	2.14	5.07
Pitch	3.82	3.79	10.03	20.79
Carbon	0.75	0.27	0.65	7.39
Total	100.00	100.00	100.00	100.00

and 20 wt percent 200 C endpoint (light) aromatics yields were obtained; that is, 60 wt percent of the feedstock was converted into premium products without significant carbon formation.

The residual products were completely aromatic and could be used for meeting the larger portion of the process fuel requirements, or distilled to electrode binder pitch (6 wt percent of feed) and to a heavy aromatic cut (7 wt percent). The tail gas (approximately 44 Scf per gallon), consisting of over 75 mole percent methane, could be used for fuel or as a natural gas substitute or supplement.

For high-temperature, vapor-phase cracking of feeds of higher molecular weight and C/H ratio than straight-run naphthas, cyclic operation consisting of alternating air blast (coke burnoff and reheat) and make (process oil introduction) periods, separated by steam purge periods, is required. In a pilot plant study, conducted under sponsorship of the American Gas Association, with a 50-80 gallons per hour residual oil capacity cyclic-regenerative thermal cracking unit consisting of two 24-inch ID generators and two 24-inch ID regenerators, it has been found that olefin yields can be substantially increased by modifications of the original Hall cycle.[12]

Production of Acetylene—Most acetylene is still produced by the calcium carbide process. The high electric energy requirements of this process (approximately 3000 kwhr per ton of calcium carbide), and the development of new processes for the production of acetylene from natural gas and petroleum hydrocarbons, have led to a re-evaluation of the economics of acetylene production.[13]

Approximately 70 percent of the acetylene produced is used for chemical purposes, primarily for the production of vinylchloride, neoprene, trichloroethylene and acrylonitrile.[1, 23] Since acetylene has a greater versatility than ethylene as a building block for petrochemical manufacture, a significant portion of this increased demand should be reflected in increased acetylene requirements.

At present, three commercial plants in the U. S. (American Cyanamid, Monsanto, and Carbon and Carbide) produce acetylene from hydrocarbon sources, all employing partial oxidation of natural gas.[32] Two small cyclic thermal cracking plants (Wulff Process Company and Koppers Company) utilize natural gas, ethane or propane as raw materials.[6, 19]

In all of the hydrocarbon conversion processes for the production of acetylene the underlying principle is the exposure of the feedstock to very high temperatures, normally in excess of 2500 F, at very short reaction times and, preferably, at low total and/or partial pressures. These process requirements are dictated by the thermodynamics and kinetics of the hydrocarbon pyrolysis reactions involved in the production of acetylene (see Figure 2).

Recent studies of acetylene production at the Institute of Gas Technology have been directed to improvement of the thermal cracking process by making it semicontinuous and capable of handling a wide range of feedstocks, such as propane, butane, natural gasoline and distillate petroleum oils. This work, based on earlier studies by Hasche[14] with indirectly-fired silicon carbide furnaces, was conducted in the laboratory pilot unit shown in Figure 5. The pyrolytic (thermal cracking) section employs a horizontal, electrically-heated furnace with a nominal heat input of 137,000 Btu per hour and capable of maintaining operating temperatures up to 3000 F with six 1¾ inch diameter x 56-inch silicon carbide elements. The reactor consists of a silicon carbide tube, 6-inch OD x 4-inch ID x 68 inches, the center of which is nearly filled with a cylindrical silicon carbide corebuster. Cracking takes place in the annulus formed between the corebuster and the inside tube wall. Each end of the reactor tube is joined to a Type 310 stainless steel casting by means of a novel, vacuum-tight compression seal developed at the Institute.

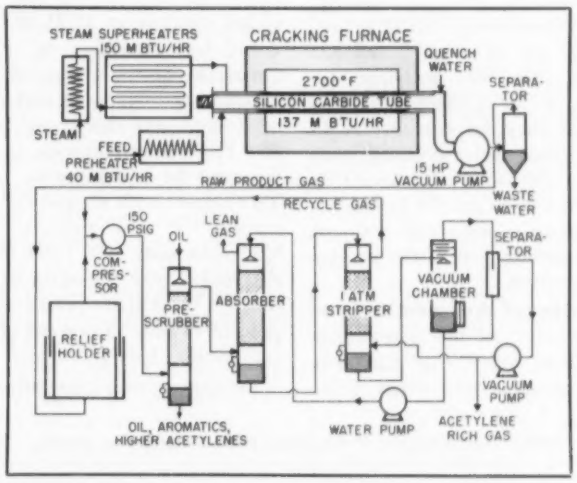


FIGURE 5—The acetylene production pilot plant using an electrically-heated silicon carbide tube for the cracking furnace. The tube operates at reduced pressure. This pilot plant used water as the quench medium.

Steam superheated to 1700-2000 F., and preheated hydrocarbon gas or vapor, are fed tangentially at high velocity into a mixing chamber in the casting on the inlet end of the reactor tube. Short residence times are obtained by use of high space velocities, low total pressures, and high steam dilutions, followed by shock quenching at the discharge end with a water spray. A water-sealed vacuum pump is employed to remove the product gases and quench water from the reactor tube.

High-purity (95 mole percent) acetylene is recovered from the product gas by—

1. Oil pre-scrubbing at 150 pounds per square inch gage to remove aromatics and higher acetylenes.

2. Selective water absorption at 150 psig.

3. Pressure letdown to one atmosphere, with or without stripping with product acetylene, to release absorbed methane, ethylene and hydrogen.

4. Desorption of dissolved acetylene at 50-100 mm of mercury total pressure.

The water is returned to the absorber by a three-stage centrifugal pump.

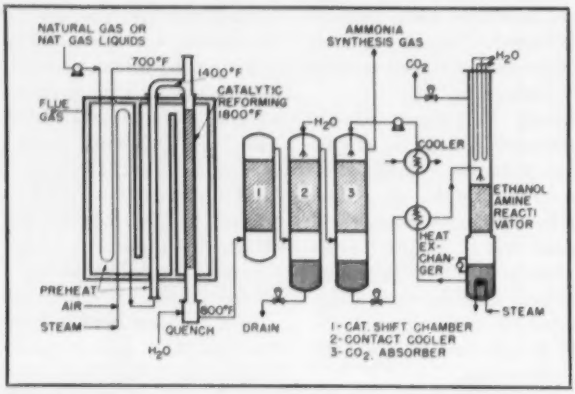


FIGURE 6—High-temperature cracking pilot plant for making ammonia synthesis gas. Notice the use of water to quench the furnace products down to the proper shift converter temperature.

Cracking is carried out continuously at steam/feed hydrocarbon ratios of 3 to 7 pounds per pound, tube temperatures to 3000 F., residence times of 0.02-0.04 seconds, and pressures of 0.2-0.6 atmospheres. The small amounts of liquid products and carbon produced remain suspended in the gas stream and are washed out with the quench water. Provision is made to admit air periodically to the cracking tube, to remove the small deposits of carbon which may form under some cracking conditions with the heavier feedstocks.

Results of typical runs with propane, butane and 12-pound RVP natural gasoline at a maximum tube temperature of approximately 2500 F. are summarized in Table 2. In these runs 100 standard cubic feet per hour of acetylene was produced from 21-27 pounds per hour of natural gas liquid feed in the presence of 80 pounds per hour of steam at 0.5 atmosphere total pressure. This corresponds to conversions of 26-35 wt percent of the feedstock to acetylene. Acetylene concentrations in the product gas were 13-19 mole percent.

Substantial quantities of ethylene were also produced under these conditions. Rates of acetylene production in the electrically-fired pilot unit have been limited only by the rate of heat input. It is anticipated that considerable increases in capacity could be obtained in a commercial gas- or oil-fired furnace with larger-diameter tubes.

In commercial multitube units with 6-inch ID x 8-inch OD x 6-foot tubes, acetylene production rates of 200 Scf per tube-hour appear to be practical. Further, the pilot plant results are based on one-pass operation through the reactor tube. It is believed that the conversion of feed to acetylene can be increased significantly by recycle of tail gas or selected tail gas components from the acetylene recovery system. In a commercial installation, it may be economical to recover ethylene under cracking conditions favorable to its formation as a coproduct, and to use the hydrogen-rich tail gas as a source of synthesis gas or for meeting part of the process fuel requirements.

Production of Ammonia Synthesis Gas—Of all the petrochemicals, synthetic anhydrous ammonia shows the greatest long-range prospect for growth.[22] On the basis of population trends and increases in industrial requirements, it is estimated that the total nitrogen demands will double in the next 10-12 years. However, at the present rate of plant expansion it is also expected that an oversupply will exist until 1957-58.[34] The present ammonia boom is based on the availability of low-cost natural gas in favorable locations. However, even at the present time, economic factors are beginning to indicate a trend away from natural gas to two new sources: fuel oil and hydrogen from catalytic petroleum refining operations. Considerable efforts are also being made to extend the utilization of coke oven gas for ammonia synthesis gas production.

The process most widely used at the present time is near-atmospheric pressure reforming of natural gas with steam, or with steam and air, over nickel catalyst at 1200-1800 F., followed by conversion of the carbon monoxide in the reformed gas with steam to hydrogen and carbon dioxide over water-gas shift catalyst at 750-850 F.[30] Carbon dioxide is generally removed by ethanolamine scrubbing. To compete with the partial oxidation process,[27] it now appears that catalytic reforming will have to be carried out under pressures of 100-150 psig.[9, 15, 26] At these pressures from 25 percent to over 35 percent of the total compression horsepower can be saved.

Further, pressure operation permits

TABLE 2—Production of Acetylene From Natural Gas Liquids

FEED	Propane	Butane		12 Lb. RVP Natural Gasoline
Operating Conditions:				
Corebuster, Diam., in.	3	3	3.5	3
Hydrocarbon Feed, lb/hr	26.8	24.5	21.0	24.0
Steam Feed, lb/hr	80.1	80.1	80.3	80.0
Steam-Hydrocarbon Feed Ratio, lb/lb	2.98	3.27	3.82	3.34
Steam Superheat Temp., F.	1715	1725	1705	1755
Hydrocarbon Preheat Temp., F.	510	545	400	625
Furnace Input, M Btu/hr.	142	137	142	135 (Est.)
Maximum Tube Temp., F.	2470	2475	2417	2543
Observed Exit Gas Stream Temp., F.	1585	1650	1570	1730
Total Pressure, atmospheres	0.490	0.509	0.557	0.476
Product Gas Partial Pressure, atmospheres	0.154	0.157	0.140	0.144
Residence Time, seconds	0.0319	0.0340	0.0269	0.0306
Operating Results:				
Raw Product Gas Rate, SCF/hr	776	705	569	738
Acetylene Production, SCF/hr	101.0	100.1	106.4	94.4
Acetylene Yield, wt % of feed	25.9	28.0	34.8	27.0
Ethylene Production, SCF/hr	87.0	87.4	85.4	51.0
Ethylene Yield, wt % of feed	23.9	25.6	29.6	15.0
Carbon Balance, %	94.0	94.8	102.3	85.1
Gas Analyses, mole %:				
Acetylene	13.0	14.2	18.7	12.8
Diacetylene	0.1	0.2	0.2	0.1
Vinylacetylene	0.1	0.3	0.3	0.2
Propadiene and Methylacetylene	0.3	0.5	0.5	0.4
Hydrogen	44.8	43.1	42.8	50.2
Methane	18.3	15.8	16.7	13.6
Ethane	0.1	0.2	0.1	0.1
Ethylene	11.2	12.4	15.0	6.9
Higher Olefins and Aromatics	1.6	1.2	1.3	1.6
CO	5.2	5.6	3.2	7.4
CO_2	1.2	0.9	0.5	1.5
N_2	4.1	5.6	0.7	5.2
Total	100.0	100.0	100.0	100.0

use of the hot carbonate process for carbon dioxide removal.[4] Low-pressure steam required for regeneration of the potassium carbonate solution can be supplied by recovery of waste heat from the shifted product gas-excess steam mixture leaving the water-gas shift reactor, while high-pressure steam or additional process heat is required for amine regeneration.

The Institute of Gas Technology has recently explored pressure catalytic cracking of natural gas and natural gasoline in its two-tube bank pilot unit (Figure 6) and in its smaller laboratory cracking units. The pilot unit consists of a 25-foot high furnace fired with six automatically controlled gas-oil combination side burners, each of 400,000 Btu-per-hour capacity, or a similar floor burner of 2,500,000 Btu-per-hour capacity. Two Type 310, 6-inch OD x 5-inch ID x 20-foot heated length vertical alloy cracking tubes, each containing 2.5 cubic feet of catalyst, are suspended from the furnace roof and fed from the top with superheated steam and air preheated to 1200-1400 F., and hydrocarbons preheated to 600-800 F.

The gas leaving the bottom of these tubes is directly water-quenched to 750 F. and introduced into a 30-inch diameter water-gas shift catalyst chamber to convert carbon monoxide and steam to hydrogen and carbon dioxide. The shifted gas, after water-cooling in a contact washer, is scrubbed at rates from 2500-4500 pounds per hour with 20 percent aqueous monoethanolamine for carbon dioxide removal in a 2-foot diameter tower packed with 1-inch Raschig rings. The amine solution is regenerated continuously at 300 F. and 40 psig in an indirectly steam-heated regenerator.

The capacity of this plant when operating on natural gas is 10,000-15,000 Scf per hour of synthesis gas after water-gas shift, depending on the amounts of air used (Table 3). The capacity drops to approximately 8000 Scf per hour when natural gasoline is used as a feed. Since the use of process air has been found to permit catalytic cracking of materials as heavy as gas oil[29] in the presence of considerable amounts of sulfur, it seems feasible to develop operating conditions for a one-step catalytic cracking operation, with propane and butane feed, which can produce suitable ammonia synthesis gas at pressures of 100-150 psig.

However, in pressure catalytic reforming, the higher molecular weight, higher C/H ratio feeds have been found to require larger quantities of excess steam to prevent carbon formation. For example, when cracking 26-pound RVP natural gasoline at 100 psig, a minimum steam/hydrocarbon ration of 10 pounds per pound should be maintained. Since this tends to greatly reduce tube capacities and thermal efficiencies, excess supplies of natural gasoline appear to be best suited for olefin, diolefin, acetylene, aromatics and natural gas substitute production by thermal cracking processes.

First presented at the Chemical, Engineering and Manufactured Gas Production Conference of the American Gas Association, New York City, May 23-25, 1955.

TABLE 3

Ammonia Synthesis Gas Production by Pressure Catalytic Cracking in IGT Pilot Plant

Feed	**Natural Gas**
Cracking Catalyst	**4.76 C F Harshaw 5% Ni, on ½" Alundum Spheres**
Water-Gas Shift Catalyst	**11.8 C F Girdler G-3 ⅛" x ⅛" Pellets**
Operating Data:	
Fuel Consumption, M Btu/hr	2580
Temperatures, F	
Steam and Air Preheat	1233
Cracking Catalyst, average	1368
Shift Catalyst, average	705
Tube Inlet Pressure, psia	91.9
Tube Discharge Pressure, psia	90.9
Process Gas Feed Rate, SCF/hr	2530
Process Steam Feed Rate, lb/hr	394
Process Air Feed Rate, SCF/hr	1390
Steam/Hydrocarbon Ratio, mole/mole	3.27
Air/Hydrocarbon Ratio, mole/mole	0.55
Shifted Gas Rate, SCF/hr	13,297
Shifted Gas Space-Time-Yield, SCF/CF cat-hr	2793
Cold Gas Efficiency, %	129.5
Carbon Balance, %	95.4
Synthesis Gas Composition After Shift and Before CO_2 Removal:	
Composition, mole %:	
N_2 + Argon	9.7
CO	2.1
CO_2	15.4
H_2	70.8
CH_4	2.0
Total	100.0
Heating Value, Btu/SCF (dry)	257
Specific Gravity, Air = 1	0.411
Natural Gas Composition, Mole %	
N_2	3.8
CO_2	0.62
He	0.22
CH_4	87.4
C_2H_6	5.2
C_3H_8	2.2
n—C_4H_{10}	0.30
i—C_4H_{10}	0.16
C_5H_{12}	0.06
C_6H_{14}	0.03
C_7H_{16}	0.01
Total	100.00
Heating Value, Btu/SCF (dry)	1045
Specific Gravity, Air = 1	0.632

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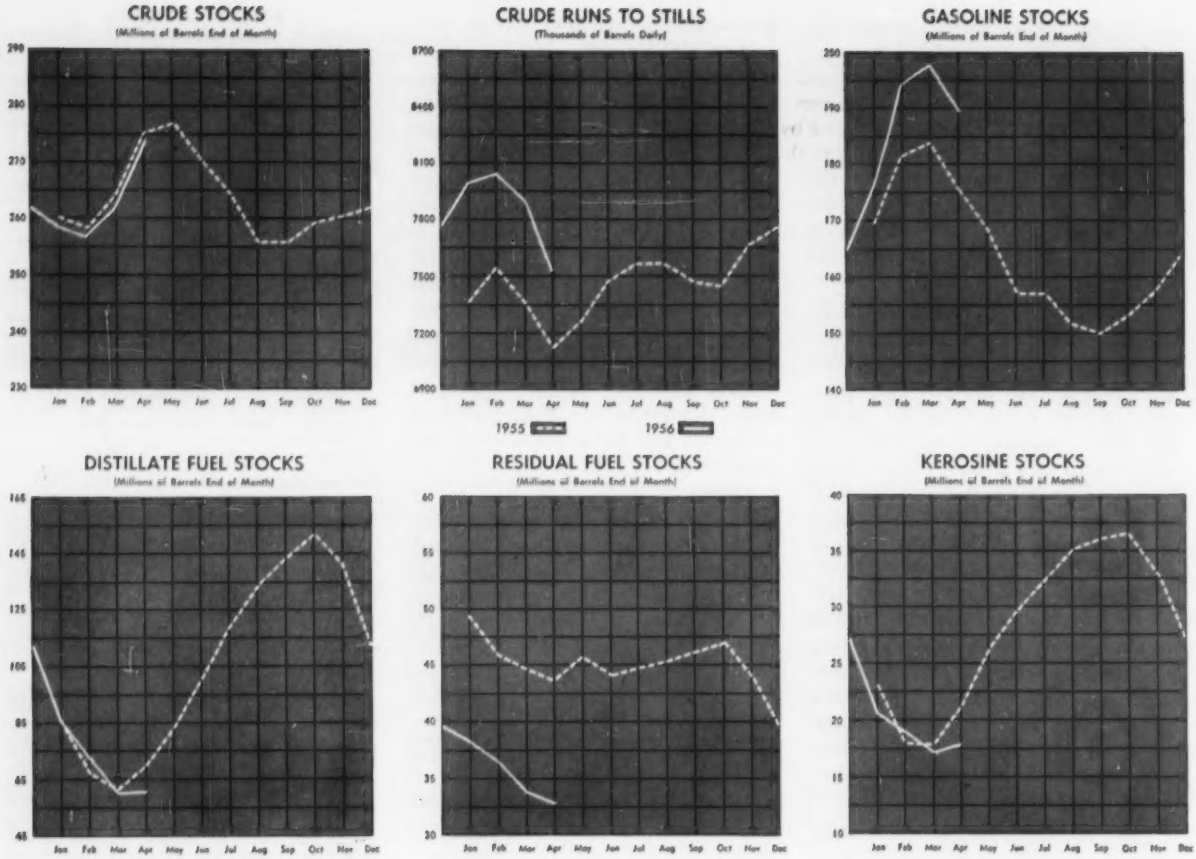
CRUDE STOCKS
(Millions of Barrels End of Month)
CRUDE RUNS TO STILLS
(Thousands of Barrels Daily)
GASOLINE STOCKS
(Millions of Barrels End of Month)
DISTILLATE FUEL STOCKS
(Millions of Barrels End of Month)
RESIDUAL FUEL STOCKS
(Millions of Barrels End of Month)
KEROSINE STOCKS
(Millions of Barrels End of Month)
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1955
1956

Taking Stock

Cecil W. Smith
Economics Editor

- Refining rates at year's low
- Gasoline output cut sharply
- Imports lowest in 5 months

MONTH	CRUDE OIL			GASOLINE		KEROSINE		DISTILLATE FUEL		RESIDUAL FUEL		DAILY IMPORTS	
	Production Daily	Runs to Stills Daily	Stocks End of Month	Production Daily	Stocks End of Month	Production Daily	Stocks End of Month	Production Daily	Stocks End of Month	Production Daily	Stocks End of Month	Crude Oil	Total Oils
1954:													
April	6,615	6,811	280,310	3,404	177,006	322	19,656	1,374	61,721	1,140	44,362	574	950
May	6,471	7,038	282,250	3,482	177,606	302	23,892	1,372	73,581	1,148	47,009	708	1,021
June	6,500	6,947	285,155	3,483	165,404	306	28,184	1,399	86,325	1,123	50,216	924	999
July	6,242	6,916	284,894	3,480	158,010	295	31,953	1,416	101,657	1,089	54,365	724	1,038
August	6,168	6,862	281,043	3,492	153,168	302	34,949	1,453	117,579	1,069	56,332	664	966
September	6,151	6,939	274,608	3,511	150,916	301	37,099	1,514	128,061	1,086	56,702	672	999
October	6,135	6,834	269,442	3,457	149,661	310	37,140	1,545	139,128	1,066	56,541	642	1,065
November	6,346	6,975	264,566	3,530	150,604	354	34,547	1,622	133,886	1,120	54,891	636	1,104
December	6,394	7,238	258,385	3,605	155,400	381	27,826	1,668	108,144	1,187	52,105	729	1,301
1955:													
January	6,761	7,379	260,156	3,639	169,562	409	23,266	1,740	86,692	1,235	49,457	739	1,348
February	6,835	7,549	258,630	3,655	181,643	374	18,291	1,847	68,513	1,239	46,042	751	1,379
March	6,886	7,374	264,430	3,543	183,972	357	18,187	1,703	62,457	1,185	44,970	742	1,319
April	6,887	7,136	275,232	3,502	175,601	312	21,486	1,534	70,139	1,110	43,838	697	1,123
May	6,677	7,281	276,948	3,605	168,751	296	26,375	1,519	83,559	1,111	45,083	742	1,137
June	6,613	7,484	270,850	3,725	157,439	269	29,830	1,628	100,652	1,080	44,398	764	1,159
July	6,632	7,580	264,601	3,824	157,079	286	32,749	1,575	119,169	1,091	44,894	860	1,161
August	6,665	7,580	256,427	3,858	151,912	290	35,292	1,621	133,675	1,090	45,480	756	1,155
September	6,731	7,483	256,269	3,784	150,194	279	36,361	1,621	143,248	1,061	46,267	829	1,218
October	6,837	7,465	267,346	3,827	153,103	309	36,705	1,612	152,288	1,123	47,040	821	1,206
November	7,014	7,692	260,707	3,867	157,871	341	33,283	1,680	141,808	1,214	44,071	823	1,322
December	7,155	7,762	265,610	3,916	165,433	395	26,770	1,765	111,333	1,286	39,174	884	1,502
1956:													
January	7,199	8,023	261,592	3,927	183,905	385	21,310	1,923	86,141	1,344	38,247	805	1,422
February	7,208	8,047	259,504	3,854	196,092	385	18,712	1,918	71,335	1,286	35,673	878	1,472
March	7,157	7,907	262,066	3,711	198,082	354	17,377	1,818	62,330	1,221	33,718	948	1,342
April	7,144	7,501	274,030	3,581	189,770	310	18,090	1,720	62,810	1,139	32,790	829	1,252
Week Ended:													
5-18-56	7,071	7,848	276,224	3,650	186,753	294	19,931	1,661	68,495	1,174	33,414	816	1,350
5-20-55	6,676	7,329	279,018	3,507	170,677	309	24,144	1,508	76,109	1,155	43,386	689	1,041

Source: Data for last two months from API; prior monthly data from Bureau of Mines. Data in thousands of barrels.

Check Effluent With Bioassay

Progress made during the past few years shows bioassay to be a valuable tool in effluent study and control.

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PROGRESS HAS been made during the past few years in the study of effluents from refineries in Oklahoma. Bioassay was used to provide a measure of strength of the wastes which in turn leads to valuable realizations.

- We can more greatly realize the harm the wastes are doing to the stream.
- We know how much wastes need to be diluted before they are rendered harmless to fish and fish food, and we can determine whether they are sufficiently diluted in the stream to be safe.
- We have a measure which indicates whether or not the effort to improve the quality of the effluent is successful.

These realizations came from Clemens and Summers 1953 study of effluents from a single refinery with respect to:

- The toxic concentration level from month to month.
- The effect of aeration and temperature on the toxic concentration levels.
- The resistance of five species of fish to the effluent.
- Making of recommendations for solving the problem.

Further progress was made during the summer months of 1954 and 1955 when the Oklahoma State Game and Fish Department conducted a survey of several oil refineries and closely related industries in the state in an effort to learn more about the toxic properties of the effluents. This was undertaken biologically by use of a bioassay method and a limited number of chemical analyses.

Some $80,000 has been spent on one waste improvement program that did not include bioassay and the effluents leaving this new development were still among the strongest in the state, killing fish at 1.3 percent.

The classification of the industries studied with respect to the products manufactured was found to be difficult. It is believed that 9 of the 37 plants involved were primarily gas plants; 2 of them were plants for reclaiming oil from salt water; and 1 of them manufactured wax entirely. The remaining 25 plants were in general larger plants and although some may have been largely designed to handle gas or oil, they were believed to have many products. These we termed refineries in general.

Methods—Effluents were collected directly before they entered the stream and were brought into the laboratory in one-gallon containers and in ground glass stoppered bottles.

The various chemical analyses were run according to methods described in Standard Methods (1946) with few exceptions. The specific conductances were determined on a conductivity bridge; the pH was determined electrometrically and the bicarbonate, carbonate, and hydroxide alkalinity was determined likewise using the double titration method with phenolpthalein and methyl orange end points. The chloride content was found by the Volhard method; sulfates were determined turbidimetrically using the Coleman Model #14 spectrophotometer. The sulfides were fixed according to Hemmeler (1934) and the total dissolved and hydrogen sulfide values were titrated and calculated as directed by Standard Methods (1946). The phenolic contents were found colorimetrically (Standard Methods) with the exception that the spectrophotometer was used.

The bioassay method (Duodoroff et al 1951) was used to measure the strength of the refinery effluents. Red shiners, *Notropis lutrensis*, largemouth black bass, *Micropterus salmoides*, and goldfish, *Carassius auratus*, of a size from 1½ to 2 inches were used as a matter of convenience. Red shiners were collected in the vicinity of the laboratory while the bass and goldfish were provided by hatcheries.

A series of known concentrations grading from pure effluents to greatly diluted effluents was set up in quart jars. Ten fish were used per concentration totaling 100 fish per experiment. All experiments were run at a constant temperature of 20 C. in order to give comparable results for each effluent. The concentration, where half of the fish were killed and half lived was determined so as to give a measure of the species as a whole and not a measure of the most tolerant individuals or the most susceptible ones. Experiments were run for 96 hours since this time showed that the experiment had reached an equilibrium and fish were no longer dying. Results were expressed in percent of wastes. In other words, the lower the percentages the stronger the effluents.

Waterfleas were used to determine the effect of the effluents on a representative fish food. Ten concentrations of varying strength were set up and ten animals were used per concentration, totaling one hundred per experiment. These animals were cultured in the laboratory and newly hatched

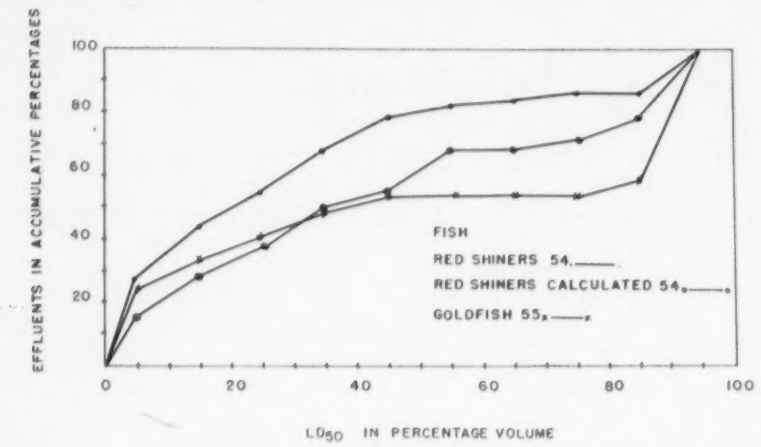

FIGURE 1—Levels of toxicity for all refinery effluents studied in Oklahoma in 1954 and 1955 using fish as a standard.

young were used in the bioassay experiments.

Bioassay Can Measure Pollution Abatement—The lethal dosages for fish food in effluents collected from refineries during 1954 and again in 1955 show that 58.0 percent of the effluents in 1954 and 48.7 percent in 1955 had to be diluted to 10 percent or below before half of the fish food organisms would live for 96 hours, Table 1. The degree of toxicity of the effluents is further seen in the fact that only approximately 20 percent of the wastes surveyed in 1954 and 28 percent in 1955 were toxic to fish food organisms when diluted one-half or less with tap water.

When the toxicity of the effluents in 1954 to fish food organisms are compared to those in 1955, it is seen that the 1954 effluents were more toxic. This is shown in Figure 2 where the total number of effluents expressed as the accumulative percents is plotted against the respective toxicity groups (0-10, 11-20, etc. to 91-100 percent). The upper curve represents the 1954 effluents, the lower the 1955 effluents. The difference in the two curves represents the improvement made in one year and the difference between the lower curve and the base line is the improvement yet to be made. If the same amount of improvement were to be made each year hence, it would take about five years to improve the effluent of Oklahoma refineries to a point where they would not be harmful to our test organism *Daphnia magna*. And it appears that improvements beyond this might be necessary.

Fish, rather than fish food organisms, can be used to determine whether improvement has been made or not, Table 2. In 1954 the test organism was a minnow, the red shiner, while a more hardy species, goldfish, were used in 1955. The red shiner has the advantage of being more commonly found than goldfish in Oklahoma streams receiving refinery effluents. On the other hand goldfish are more easily obtained from hatcheries and do not have to be seined from streams and are more easily maintained under laboratory conditions.

The total number of effluents expressed as accumulative percentages has been plotted in Figure 1 against the respective toxicity groups from 0 to 100 percent, using the red shiner in 1954 and the goldfish in 1955. When the 1954 curve is compared with the one of 1955 a large variation is seen.

However, not all of the differences are due to a change in the nature of the refinery effluents since the goldfish is a more tolerant species. Clemens and Summers (1953) exposed red shiners and goldfish to the same effluent under similar conditions and found that the LD_{50} of the goldfish was 33.1 percent while that of the red shiner was 18.8 percent. Thus the goldfish could tolerate 1.76 times as much of the effluent as the red shiner.

When the 1954 curve in Figure 1 is corrected by a factor 1.76, the curve thus calculated lies for the most part above the 1955 curve.

The amount the calculated curve of 1954 lies above the 1955 curve is taken to represent the amount the effluents have improved in one year and the difference between the 1955 curve and the base line is taken to represent the improvement yet to be made when the goldfish is used as a standard organism.

The degree of improvement may be more in some instances and less in others depending on the relationship between the respective LD_{50} for the red shiner and the goldfish in various effluents. If the same amount of improvement were to be made each year hence, theoretically it would take about four years to improve the effluents of Oklahoma refineries to a point where they would not be harmful to our test organisms.

Obviously in a stream environment many other kinds of organisms are involved and the relationship of their susceptibility to the susceptibility of

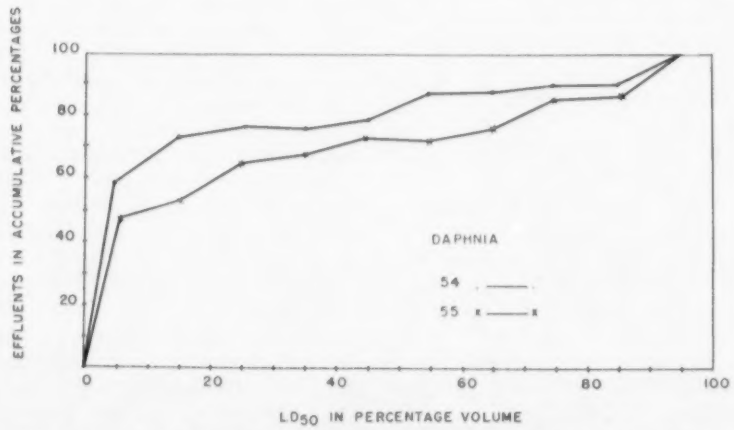

FIGURE 2—Levels of toxicity for all refinery effluents studied in Oklahoma in 1954 and 1955 using Daphnia magna, a fish food as a standard.

the test organisms would have to be established before a condition of maximum disposal with minimum harm to fish and wildlife could be evaluated.

It is perhaps best to view the fish food organism, *Daphnia magna*, as a more useful standard than red shiners or goldfish, since the lethal dosages for *Daphnia* are lower than those for the fish and will therefore include the lethal dosages for a wider variety of organisms. The LD_{50} for *Daphnia magna* was 19.0 percent lower than those of the red shiner in 1954 and was 36.1 percent lower than those of the goldfish in 1955.

This provides a second opportunity of evaluating a mean difference in susceptibility of the red shiner and the goldfish in refinery effluents. The goldfish were 1.89 times more tolerant than the red shiner as compared to 1.76 times in the previously mentioned determination.

Bioassay Can Detect the Toxic Sources of Refinery Effluents—Since many refineries have more than one outlet for the various wastes, it is necessary to determine the degree of toxicity for each outlet. In the study made it was found that a considerable variation within a refinery could exist in terms of effluent toxicity toward fish and fish food. Ranges as large as 4.5 percent to 100 percent for fish, Table 2, and 3.1 percent to 73.5 percent for fish food, Table 1, were found to exist within single refineries. It is evident that the toxic level for each outlet should be determined.

Since the chemical nature of the effluents from refinery wastes involves materials of a highly complex organic nature, chemical analyses of the various effluents within a refinery often prove difficult and usually require a skilled organic chemist. The procedures, equipment and personnel necessary for these determinations also prove expensive.

Results from such determinations are usually insufficient since many of the various toxic components cannot be readily separated and identified and since the toxicity of these components to various forms of aquatic life are generally unknown. And too, many of these determinations are lengthy and by the time usable data has been derived it may have lost the importance.

The bioassay method provides a relatively rapid and effective method for measuring the degree of toxicity for each effluent. It may be used to screen the toxic from the non-toxic effluents which will eliminate many chemical determinations on those effluents which prove to be non-toxic. The toxic ingredients may then be determined by chemical analyses. Once the harmful chemical agents are known, steps may then be taken to remove, detoxify or at least diminish the amounts of these agents in the plant waste products.

After the deleterious agents are known then only a single and perhaps rapid chemical determination need be run at frequent intervals to determine the continued success of the treatment, with a periodic bioassay to see if other substances are creating any harmful effects.

Or in the case, where long involved chemical analyses are required, bioassay experiments may be substituted. The bioassay determination will also indicate the degree of toxicity to fish and the dilution necessary to render effluents non-toxic.

Probably the question in most minds is, "What are the toxic ingredients of

TABLE 1—Lethal dosages for water fleas in refinery effluents collected in 1954-55

Refinery	Lethal Dosage—1954 Station				Lethal Dosage—1955 Station			
	A	B	C	D	A	B	C	D
1	13.6	21.5	52.0	.....	2.3	0.6	20.6	.....
2	7.2	.....	.....	.....	.....	.....	.....	.....
3	19.1	.....	.....	.....	8.7	.....	.....	.....
4	.....	.....	.....	.....	12.9	.....	.....	.....
5	No kill	.....	.....	.....	No kill	.....	.....	.....
6	.....	.....	.....	.....	1.9	.....	.....	.....
7	0.02	.....	.....	.....	0.33	.....	.....	.....
8	9.36	.....	.....	.....	3.0	3.4	.....	.....
9	.....	.....	.....	.....	3.7	.....	.....	.....
10	.....	.....	.....	.....	No kill	.....	.....	.....
11	0.5	.....	.....	.....	1.2	.....	.....	.....
12	.....	.....	.....	.....	36.9	.....	.....	.....
13	.....	.....	.....	.....	No kill	.....	.....	.....
14	0.7	.....	.....	.....	4.7	.....	.....	.....
15	4.3	.....	.....	.....	.....	.....	.....	.....
16	.....	4.4	.....	.....	25.0	46.3	.....	.....
17	2.9	0.4	.....	.....	5.3	.....	.....	.....
18	11.4	.....	.....	.....	.....	.....	.....	.....
19	.....	.....	.....	.....	4.1	.....	.....	.....
20	3.9	.....	.....	.....	2.8	.....	.....	.....
21	10.5	.....	.....	.....	20.0	.....	.....	.....
22	2.5	3.9	.....	.....	25.0	87.5	2.3	25.1
23	72.4	95.5	.....	.....	No kill	45.0	.....	.....
24	14.0	9.0	3.3	1.5	16.6	.....	76.7	1.1
25	5.7	8.4	.....	.....	9.7	0.4	.....	.....
26	7.8	52.2	57.2	.....	73.5	3.1	1.8	5.3
27	1.1	.....	.....	.....	1.5	.....	.....	.....
28	0.2	.....	.....	.....	.....	.....	.....	.....
29	14.4	No kill	43.5	.....	63.3	.....	73.5	.....
30	2.9	.....	.....	.....	0.6	.....	.....	.....
31	99.4	.....	.....	.....	No kill	.....	.....	.....
32	8.6	.....	.....	.....	76.5	.....	.....	.....

TABLE 2—Lethal dosages for fish in refinery effluents collected in 1954-55

Refinery	Lethal Dosage—1954 Station				Lethal Dosage—1955 Station Collected			
	A	B	C	D	A	B	C	D
1	31.3	31.3	No kill	.....	No kill	4.5	40.0	.....
2	18.2	.....	.....	.....	.....	.....	.....	.....
3	33.2	33.8	.....	.....	.....	5.5[1]	.....	.....
4	3.4	.....	.....	.....	14.7	.....	.....	.....
5	31.3	.....	.....	.....	No kill	.....	.....	.....
6	.....	.....	.....	.....	37.5	.....	.....	.....
7	8.1	.....	.....	.....	3.7	.....	.....	.....
8	No kill	.....	.....	.....	23.7	4.8	60.0	.....
9	.....	.....	.....	.....	21.3[1]	.....	.....	.....
10	31.3	.....	.....	.....	No kill	.....	.....	.....
11	8.4	.....	.....	.....	13.1	.....	.....	.....
12	.....	.....	.....	.....	87.0	.....	.....	.....
13	No kill	.....	.....	.....	No kill	.....	.....	.....
14	18.2	.....	.....	.....	35.3	.....	.....	.....
15	24.0	.....	.....	.....	.....	.....	.....	.....
16	No kill	21.9	.....	.....	No kill	.....	.....	.....
17	4.6	5.9	8.7	.....	1.3	.....	.....	.....
18	31.3	.....	.....	.....	.....	.....	.....	.....
19	11.5	.....	.....	.....	3.5[1]	.....	.....	.....
20	4.0	.....	.....	.....	1.0	.....	.....	.....
21	19.0	.....	.....	.....	49.8	.....	.....	.....
22	50.0	17.0	0.52	11.0	No kill	41.6	5.6	24.0
23	79.4	92.5	.....	.....	100	100	.....	.....
24	15.8	66.0	3.3	20.7	22.4	.....	No kill	No kill
25	28.7	1.6	.....	.....	18.6	7.4	.....	.....
26	50.0	42.0	47.0	.....	73.2	No kill	No kill	No kill
27	2.5	.....	.....	.....	4.8	.....	.....	.....
28	1.3	5.0	.....	.....	.....	.....	.....	.....
29	26.5	54.7	50.0	.....	No kill	.....	No kill	.....
30	5.7	.....	.....	.....	2.0	.....	.....	.....
31	No kill	.....	.....	.....	No kill	.....	.....	.....
32	58.2	.....	.....	.....	No kill	.....	.....	.....

[1] Bass used as test organism.

the effluents?" Fairly lengthy lists have been compiled of various chemicals found in the effluents of refineries and this is backed by a moderate amount of toxicity studies. The State of California has made a good beginning at this in their 1952 publication "Water Quality Criteria."

However, there is much information to be gleaned before the problem is solved.

1. More toxicity experiments are needed on inorganic and particularly organic compounds involving the various biological components found in the receiving waters.
2. More attention needs to be given to synergistic and antagonistic effects of combined components in each effluent.
3. The ultimate damage to the stream is of prime consideration and is revealed only by field studies of the streams in question.

Conservation agencies the country over are responsible to the people, the sportsman, for the welfare of the fish and wildlife in and along the streams. Industry is responsible for the quality of the material that is released into the stream.

The present survey was conducted by the Oklahoma Game and Fish Department and they have been primarily concerned with the strength of the effluents being released into a stream. In cases where the effluents are strong, a bioassay test can quickly determine as to whether harm is being done to the stream or not.

They have not been primarily concerned with the determination of the toxic ingredients. They feel that the company has a responsibility here. However, a limited number of general chemical analyses were made and the results of these will be compared to the lethal dosage of the effluent.

Of the 92 effluents for which chloride concentrations are known, 77 of the effluents had chloride concentration below 1000 ppm. Only one was over 5000 ppm chloride and it was known that this effluent received brine from oil wells. Clemens and Jones (1955) have reported the lethal dosage of chlorides to a number of fish and fish food organisms to be well over 1000 ppm chloride.

Of the 91 effluents for which sulfate concentrations were known 86 of the effluents has a sulfate concentration below 1000 ppm SO_4 while the sulfate values for the remaining effluents were between 1000 and 1640 ppm.

Since the pH of natural waters usually is found to be within a range of 6.5 to 8.5, effluents below this range are referred to as acid ones and those above as caustic. An evaluation of the 91 pH determinations showed that eleven ranged from 1.5 to 6.4, 47 from 6.5 to 8.5 and 33 from 8.6 to 11.4. It appears that caustics are more prevalent than acids. Of the caustic effluents determined, seven were from 8.6 to 8.9, eleven were from 10.0 to 10.9 and six were from 11.0 to 11.4.

The 1955 survey indicated that 7 effluents had a pH that had changed from the caustic group to the 6.5 to 8.5 range while 2 had changed from the acid group to the normal range. Four had changed from the 6.5 to 8.5 group to the caustic range, while 1 had changed from the 6.5 to 8.5 range to the acid group. Thus 9 showed improvement while 5 had not shown improvement. Actual values indicate 6 had shown a large improvement while in the other a little improvement was indicated. Some improvement was also shown in the bioassay experiments.

How do pH values correspond with the lethal dosage? Of the lethal dosages determined for waterfleas in 26 effluents where the pH was above 8.5, 17 effluents were found to have a lethal dosage below 10 percent, two were found to be in the 11 to 20 percent range, two in the 2 to 30 percent range, two in the 41 to 50 percent range and one in the 61 to 70 percent and two in the 71 to 80 percent range.

Of the lethal dosages determined for waterfleas in 13 effluents where the pH was below 6.5, eleven effluents had a lethal dosage below 10 percent and all were below 20 percent.

The lethal dosage of effluents where the pH ranged from 6.5 to 8.5 varied from less than 10 percent to 100 percent. Of the 38 effluents whose pH ranged from 6.5 to 8.5, 8 had a lethal dosage between 91 and 100 percent, 3 between 71 and 80 percent, 3 between 51 and 60 percent, 1 from 41 and 50 percent, 1 between 31 and 40 percent, 3 between 21 and 30 percent, 4 between 11 and 20 percent and 14 between 0 and 10 percent.

The situation was similar in fish, i.e. the effluents whose pH are out of the range from 6.5 to 8.5 are more likely to be more toxic than effluents within the range. pH may in all probability not be a primary toxic condition but rather one that synergizes or antagonizes the action of other toxic ingredients.

Phenols were determined in thirty effluents having relatively high toxicities and nineteen were found to contain various amounts up to 18.5 ppm, Table 3. Insofar as the literature reports that 10 ppm phenol to be toxic to some kinds of fish the above determined values have little meaning as to whether or not phenol is the toxic ingredient of the effluent.

The LD_{50} for channel catfish 1½ inches long under the same conditions was 16.7 percent in phenol and 10.0 percent in O-cresol. Anderson (1944) reports 9.0 ppm phenol to be the LD_{50} for newly hatched *Daphnia magna* in Lake Erie water. On this basis there was only one effluent containing enough phenol to be toxic to *Daphnia*. However, phenolic substances are important in that they taint the flesh of fish, and should therefore be removed from the effluents.

Specific conductance determinations were run to give some indication of the dissolved salts and solids in the refinery effluents and particularly the ions of sodium, potassium, calcium, chloride, sulfate, and various others. It has been reported by Hart et al (1945), using Ellis's data that 95 percent of the natural waters of the

TABLE 3

Concentrations of phenolic compounds with respect to the lethal dosages of waterfleas and fish in 1955

Refinery	Phenol Compd. Concentration ppm	LD_{50} Fish	LD_{50} Waterfleas
10A	1.8	No kill	No kill
17A	3.0	1.3	5.3
17B	1.0	....	....
20A	7.5	1.0	2.8
21A	3.5	49.8	20.0
22C	1.5	5.6	2.3
22D	1.0	24.0	25.1
23A	5.5	No kill	No kill
23B	18.5	No kill	45.0
24A	3.0	22.4	16.6
24C	5.5	No kill	76.7
24D	6.1	No kill	1.1
25A	0.5	18.6	9.7
26A	6.5	73.2	73.5
26B	0.5	No kill	3.1
26C	4.5	No kill	1.8
26D	0.8	No kill	5.3
29A	1.5	No kill	63.3
29C	1.0	No kill	73.5

United States have a specific conductance of under 1100 x 10^{-6} mhos.

Ellis further reported that the approximate value of 4000 x 10^{-6} mhos was the upper limit tolerated by fish in mixtures of sodium, magnesium and calcium compounds in gas-well water. He also concluded that conductances in excess of 2000 x 10^{-6} mhos were indicative of the presence of acid or salt pollution of various kinds.

In the present study of refinery effluents the range of specific conductances was found to be from 96.1 x 10^{-6} mhos to 18,518 x 10^{-6} mhos. Thirty-five percent of the effluents had a specific conductance above 2000 x 10^{-6} mhos, while 23 percent had a specific conductance above 4000 x 10^{-6} mhos, the maximum tolerable allowance set by Ellis (1937). This is taken to mean that about ⅓ to ¼ of the effluents are too high in total inorganic content.

In all cases except two where the specific conductance was over 4000 x 10^{-6} mhos wastes had to be diluted to at least 50 percent before half of the fish would live for 96 hours. These results substantiate those of Ellis (1937). However, when the specific conductance was below 4000 x 10^{-6} mhos, wastes frequently were toxic. Since organic compounds do not usually dissociate in water, the specific conductance will give no indication of the organic material content. Since the organic matter present could well be toxic a low specific conductance could not be used as an indicator of non-polluted water.

In the 1955 survey sulfide values were determined in an effort to find some recognizable factor in refinery effluents which was responsible for damage done. Determinations were made and results calculated to give the part per million of total sulfide (includes all of the sulfide in the effluent), dissolved sulfides, and sulfide present as H_2S. Hence the total sulfide values are the total of the dissolved sulfide, the hydrogen sulfide, and any insoluble sulfide material.

The range of total sulfides was found to be 0-172 with 0.09 the lowest value of sulfide present; the dissolved sulfide range was from 0-142; and for the hydrogen sulfide 0-46.9, Table 4. The median levels calculated were as follows: (1) total 14.29 (2) dissolved 13.63 (3) H_2S 4.12. The low value for the H_2S is due to the fact that as the pH of the effluent is increased the value of the H_2S becomes smaller and the pH's of refinery wastes are, in general, above 8.0 and at this pH approximately only 30 percent of dissolved sulfide exists as H_2S.

It has been reported that concentrations above 7.0 ppm H_2S are lethal to fish and the minimum lethal concentration for fish food has been reported as 1 ppm H_2S (State Water Pollution Control Board, 1952). Of eleven refinery effluents where H_2S values were present, ten of the effluents had median LD_{50} values of 76.7 percent and a median H_2S value of only 0.24 ppm H_2S.

In attempting to correlate LD_{50} values and H_2S values some correlation was evident. Of 17 refineries, where values for LD_{50} and H_2S were both available, 11 had LD_{50} values of less than 50 percent, with an H_2S range of 0.87 to 5.7.

However, it is probable that the toxicity in many of these cases was not due to H_2S alone but to other factors in the effluent. The remaining six refineries all had LD_{50} values of between 90 and 100 percent. Of these effluents the range of H_2S was from 0.09 to 6.0 ppm H_2S. There were two effluents having H_2S values greater than 4.12 ppm, one with 6 ppm and the other 4.7 ppm H_2S.

TABLE 4

Concentrations of hydrogen sulfide with respect to the lethal dosages of waterfleas and fish in 1955

Refinery and Station	H_2S Conc. ppm's	MTT Fish	MTT Waterflea
1A	6.0	No kill	2.3
1B	5.7	4.5	0.6
4	46.9	14.7	12.9
20A	1.08	1.0	....
21A	0.42	49.8	....
22A	0.12	No kill	25.0
22B	0.47	41.6	....
22C	0.87	5.6	....
22D	0.98	24.0	25.1
24A	0.96	22.4	16.6
24C	0.24	No kill	76.7
24D	0.09	No kill	....
25A	0.003	18.6	9.7
25B	0.47	7.4	0.36
26B	4.9	No kill	3.1
26D	0.7	No kill	5.3

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Meet the Authors

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A Refiner's Reaction to RP-500

Problems involved in classifying hazardous locations and recommendations for future improvements in refinery electrical service are discussed.

F. C. Somers
The Atlantic Refining Company, Philadelphia

API STANDARD RP-500, "Recommended Practice for Classification of Areas for Electrical Installations in Petroleum Refineries," was published in 1955. Now, one year later, it seems appropriate to take stock of what has been accomplished. To do this, it is necessary to answer the following questions:

- To what extent is RP-500 being used?
- How is it being used?
- What are the problems in using it?
- What are its shortcomings?
- What is the next logical step?

The key to further progress:

Equipment made specifically for Division 2 locations.

Non-explosion-proof equipment is . . .

- **Easier to maintain**
- **Often safer**
- **Lends itself to refinements in relaying and automatic control**

Background—In 1947 the National Electrical Code Article 500 dealing with hazardous areas was revised to recognize the now familiar Division 1 and 2 concept. In simple terms, a Division 1 location may be hazardous under "normal" conditions, while a Division 2 location may be hazardous only under abnormal conditions. Requirements for electrical installations in Division 2 locations are less stringent than for Division 1. A few petroleum refiners had adopted the Division 1 and 2 concept some years prior to 1947. For them the NEC revision meant little beyond official recognition. For the rest of the refining industry, it provided a basis for a significant change in electrical practice.

Surprisingly few changes materialized. Ingrained conservatism and human inertia undoubtedly weighed heavily. However, it soon became apparent that the real stumbling block was the lack of an adequate and recognized basis acceptable to refiner and electrical inspector alike for properly classifying a location. In 1951 the API determined to provide the missing link.

Accordingly, the API Subcommittee on Electrical Equipment was asked to develop a sound, logical, and consistent basis for determining the existence, degree, and extent of a classified location. This effort culminated in 1955 with the publication of API Standard RP-500.

RP-500 provides an easily-understood discussion of the factors that must be considered in classifying areas; provides a straightforward questionnaire-type procedure for determining the proper classification of an area; and finally, by means of simple, clearly dimensioned diagrams, provides a method for establishing the extent of a classified area. In short, the missing link has been forged.

Extent of Use—RP-500 is being widely used. A recent informal survey indicated the majority of the refining industry is either using or planning to use RP-500 as a basis for classifying areas. However, there are some who believe RP-500, in recommending for "average refinery conditions," is too conservative, and they prefer to work to a less stringent minimum for certain types of installations. Although no survey was made, some chemical concerns are also known to be using RP-500. Favorable comments have been heard from electrical inspectors, code enforcement agencies, and code-making bodies. Some 1,200 copies of RP-500 have been distributed.

How It Is Used—Perhaps a good way to illustrate how RP-500 is being used is to see what The Atlantic Refining Company is doing with it, especially since it is believed to be representative of what others are doing. The first step was to agree that as a matter of policy we would henceforth use RP-500 as a basis for classifying areas. The mechanics of making classifications are described in some detail in a paper by Dr. Goldsmith.[1] In essence we end up with a block plan marked to show the classification of all locations and their boundaries.

In working out the proper classification, we give careful consideration to terrain, the nature and location of nearby facilities, and the probable future use of adjacent vacant areas. If the project is engineered by Atlantic, the classification is made by the supervisors of our electrical engineering and drafting sections. If the job is contract engineered, the classification is the responsibility of the contractor.

Regardless of who does the engineering, the marked-up block plan is reviewed and approved by the managers of our design, engineering research, and construction divisions. This has been an important part of the procedure, as it has provided a stabilizing influence and close check

on performance during the transition period.

The procedure also provides for review and comment by those responsible for operation of the plant. Once the classification has been approved, we believe the NEC and our own standards and practices adequately define the type of electrical equipment and installation required for each area classification and we rely on routine supervision to see the job through.

Problems—There have been several problems in using RP-500. One of these has been getting people to depart from long-established patterns of doing things. For some this particular field seems to be one in which resistance to change is instinctive. They study RP-500 and profess to understand it, but somehow they fail to move out of the well-worn groove. This stems in part from the fact that in many quarters the process of classifying locations has been an art shrouded in mystery and confusion, much of which may have been a reflection of the true state of mind of the practitioner.

Problems of this type require prodding from above, and fortunately RP-500 is sufficiently down to earth to be useful to the upper levels of an organization. From personal experience we found many locations that should have been classified Division 2 on the basis of RP-500 were being called Division 1 because of past custom. This was characteristic of early efforts at using RP-500.

Later we found that although a location was properly classified as Division 2, there was a tendency to make the installation and equipment as for a Division 1 location. The unnecessary use of explosion-proof conduit fittings in Division 2 locations has been a very tenacious problem and we still find an occasional slip.

Another problem has involved applying the principles of RP-500 to a situation not specifically covered by the publication. A typical example is classifying a location containing a non-electrical source of ignition such as a furnace. Does the furnace make the location "safe"? Some people believe it does and are able to advance good arguments in support of their views. Others feel that a furnace should not be a factor in classifying on the basis that the furnace has nothing to do with whether or not a flammable mixture may be present.

Those adhering to the latter view tend to use explosion-proof enclosures on sparking devices to avoid adding electrical sources of ignition to such locations. Similar problems are created by the presence of internal combustion engines.

The laboratory is another example of a situation not specifically covered by RP-500. Laboratories with explosion-proof electrical equipment side by side with bunsen burners have been all too common in the past. By literal interpretation it can and has been argued that RP-500 recommends such installations.

It is reasoned that flammable materials are being handled in open containers and therefore the location must be classified. The important factor which is discussed in RP-500 but overlooked by such a narrow view is the quantity of flammable material that may be present.

Refinery roadways have created some problems. There have been instances in which the boundaries of classified locations have extended into or completely across a main refinery roadway. This has been most noticeable in older plants where space is at a premium. One approach has been to exercise the "judgment" frequently referred to in RP-500 and reduce the clearance from 100 to 50 feet on the basis that the outermost 50 feet, which is limited to 2 feet above grade, is only required for unusual situations such as handling liquefied gases.

Rearrangement of equipment to locate the source of hazard further from the road has been the solution in a number of cases. Relocating the entire plant or the road has also been accomplished occasionally. While RP-500 is not intended to deal with non-electrical matters such as general plant layout, it is high-lighting the fact that the restrictions on electrical and non-electrical sources of ignition are not always consistent. Whether or not they should be consistent is far afield from this discussion.

However, it is clear that the importance of good plant layout, adequate spacing between plants, and proper location of roadways is receiving some emphasis as a result of using RP-500.

Short Comings—It was the intention of the Subcommittee on Electrical Equipment to periodically revise RP-500 in light of experience in using it. Over a period of time there will undoubtedly be improvements both editorially and technically; perhaps the scope may be broadened; and the recommendations themselves may be changed if justified by experience. A group within the API recently drafted a proposed revision which does not appreciably alter the recommendations or the form of RP-500 but which does add quite a bit of additional discussion and information to the text. The proposed changes to the recommendations will result in minor revisions to the diagrams. Probably the most significant change is the proposal to reduce the horizontal extent of a classified area from 100 feet to 50 feet for the average case.

As proposed, the diagrams would continue to show the classified area as extending 100 feet horizontally from a source of hazard, but the outermost 50 feet would be shown dotted with a note that this additional area be classified only where release of large volumes of volatile products may occur. Changes in the text are proposed to further clarify the fact that RP-500 is intended to apply to refinery installations only.

These changes are largely editorial except for a paragraph explaining

Meet the Author

FRANK C. SOMERS, manager of the Engineering Research division of The Atlantic Refining Company's Engineering and Construction department, joined the company in 1953, after ten years with Standard Oil Development Company. An electrical engineering graduate from Duke University, he also holds a masters degree from Massachusetts Institute of Technology. Somers' other industrial experience includes service with Communications Development Company in Camden, N. J., and Lago Oil & Transportation Company at Curacao in the Netherlands West Indies.

that high processing rates at elevated temperatures and pressures are peculiar to refineries and dictate standards of design not warranted in all other operations of the petroleum industry. It is also proposed to expand the text to include a more complete discussion of flammable liquids or vapors and their behavior when released to the atmosphere.

The differences between fixed gases and liquid petroleum gases are discussed with emphasis on the need for conservatism in establishing the extent of a classified area when the liquid petroleum gases are involved.

One purpose in discussing the presently proposed revisions is to make the point that the changes are minor, which is rather conclusive evidence that experience in using RP-500 has demonstrated its fundamental soundness. It is believed that the future will bring further refinements, but no drastic changes in concept or principle. The use of RP-500 in the day-to-day classification of areas is also settling down to a routine business.

Problems in educating personnel to intelligent use of the material are still with us but are diminishing and will eventually disappear. While RP-500 is being used at present by the majority of the refining industry, the future will probably see it become nearly universal throughout the industry.

Thus, on the evidence available today, there are no signs of anything drastically new ahead in either RP-500 itself or its application. This seems to indicate that we must look to something other than RP-500 for further advancements in electrical installations for petroleum refineries.

Next Logical Step—The author believes that the next major improvement will be in equipment for Division 2 locations. One consequence of RP-500 has been to make engineers increasingly aware that completely explosion-proof installations are not only unnecessary in many cases but also are not necessarily the safest solution.

Safety is a broad problem of which the ignition hazard is only one phase. For instance, an unexpected interruption of electric service can disrupt operations and create the "abnormal" conditions we seek to guard against. Protection of personnel against electric shock is another phase of the over-all safety problem. Provisions to maintain equipment properly and safely are still another consideration. Considered in the light of these requirements, many of us believe that explosion-proof equipment installations, in addition to being costly, are far from ideal in many respects. The selection or range of devices normally available in explosion-proof construction is too limited to permit many of the refinements in relaying and automatic control.

Such equipment is difficult to maintain and once opened provides little protection against electric shock. Problems associated with a multitude of enclosure bolts are familiar to all. The lack of a positive check on the integrity of equipment is a real concern. Missing or loose cover bolts, proper oil level, proper clearance and surface condition of explosion-proof enclosure joints, condition of seals, and so forth, all depend entirely on the human element. These are some of the shortcomings of this type of equipment other than cost.

It was hoped that RP500, in providing a sound basis for classifying locations as Division 2 rather than Division 1, would encourage better over-all electrical installations with less money being spent on costly explosion-proof equipment and more being spent on making the installation more reliable, easier to maintain, and safer to work on. Some progress is being made in this direction, but it is becoming apparent that the lack of electrical equipment for Division 2 locations is a real problem.

As things stand today, the choice is largely between a conventional explosion-proof installation or an installation using general-purpose equipment either modified to minimize the chance of ignition or located in an area where ignition is not a problem. One widely used approach is to locate general-purpose equipment in a room or building kept under positive pressure. Usually this is accomplished by providing a blower taking suction from a "safe" source of air and discharging into the building or room to be pressurized.

In addition to the cost of the building and ventilating system, there is the problem of seeing that the source of air is safe at all times and that all doors and windows in the building are kept closed while equipment is energized. Another approach has been to locate general-purpose equipment in areas sufficiently remote to be unclassified.

In many refineries, particularly the older ones, the concentration of plants is such that an unclassified area is difficult to find. Where it has been reasonable to locate equipment remotely, it has been accomplished at the expense of branch circuit costs and losses. The extent to which part of the industry is going to try and improve on the old conventional explosion-proof installation is a good measure of the benefits to be realized, and at the same time the expedients being used clearly indicate that equipment-wise, the ideal answer has not yet been found.

Plainly, the situation calls for equipment made specifically for Division 2 locations. Such equipment, to get acceptance, must provide all the desirable features of general-purpose equipment with none of the disadvantages of explosion-proof equipment. This is the key needed to open the way to further important progress. Until this need is satisfied, we can expect a continuation of the cumbersome expedients forced upon us by the limitations of presently available equipment.

Meanwhile the petroleum industry will continue to get something less than the best possible electrical installation for its dollar. Like the problem of classifying areas, the equipment problem has been with us for years. We learned from our experience on RP-500 that the initiative has got to come from within the oil industry. The same is true of the equipment problem. We must spark the drive.

This paper was originally presented at the API Division of Refining Meeting in Montreal, May 14, 1956.

LITERATURE CITED

[1] Goldsmith, Dr. L. M., Current Practices in Classifying Areas for Electrical Installations, *Electrical Engineering*, January, 1956.

One of many advantages of 90/10 Cupro-Nickel.

WELDABILITY.

Welding head on filter shell

One of the relatively new copper base alloys is 90/10 Cupro-Nickel, which is coming into increased use as a result of experience with it. Revere offers it in sheet and plate, pipe and tube. It is highly resistant to corrosion and erosion, particularly in salt or brackish water. In addition it can be cold or hot worked, welded, soldered and polished. Because its nickel content is less than the older 70/30 alloy, it is priced lower.

The item shown here is a 90/10 Cupro-Nickel filter for aviation gasoline, designed and fabricated by the Warner Lewis Company, Division of Fram Corporation, Tulsa, Oklahoma, for the U. S. Navy. Heads and shell are 1⅛" thick. Revere was given the opportunity to collaborate with the Warner Lewis manufacturers on welding, which was successfully accomplished by the metallic arc process, using Inco 70/30 Cupro-Nickel electrodes. The vertical weld on the shell was X-rayed 100% and found satisfactory to pass Navy inspection. Because of the thickness of the metal, it was decided to form the heads hot at around 1690° F. The forming was done by the Hackney Iron & Steel Co., Enid, Okla., which also consulted with Revere.

Warner Lewis Company of Tulsa, with representatives in 30 cities, are specializing on all types of alloy design and fabrication and inquiries of this nature are invited.

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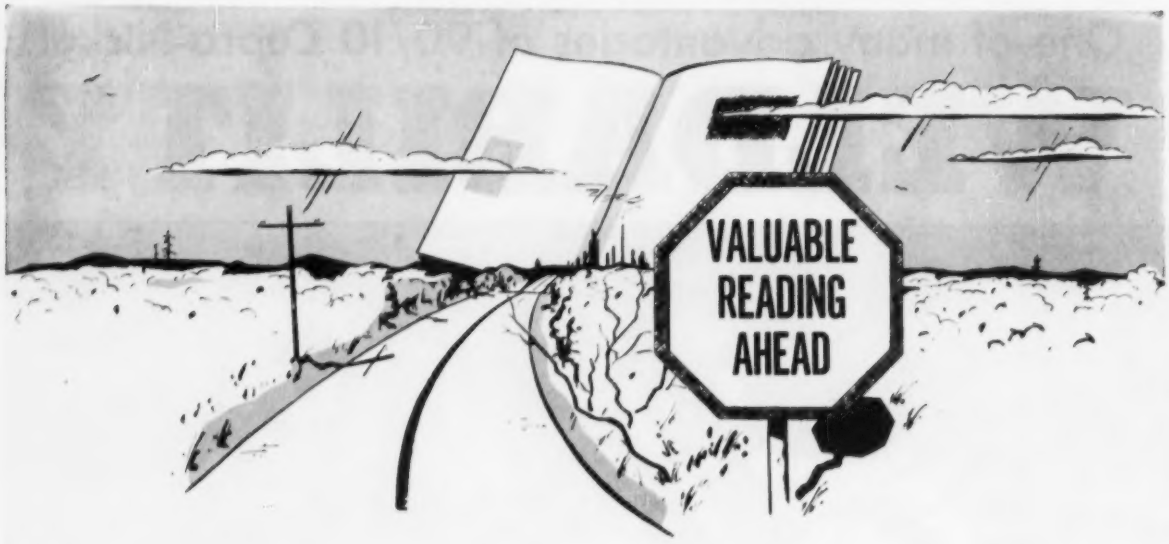


Want to Save Money?

ONE COMPANY recently saved almost 12,000 square feet of insulation on a stress-relieving job by using the same insulation for each of four large vessels. How it was done is covered in "How to Do It."

Keep Going to Page 208.

Texaco Scores a First

THE FIRST privately-financed jet-fuel laboratory in the U. S. has been opened at The Texas Company's Beacon, N. Y., research center. Texaco expects the new installation, built at a cost of $250,000, to step up its development of fuels for all turbine engines. For a description of this plant, see "Who's Building."

Keep Going to Page 214.

And Now What?

THE PROBLEM of expressing octane numbers above 100 was one of the subjects taken up at the Division of Refining's Montreal meeting. And one of the points on which most refiners agreed was that a decision on a scale for indicating antiknock quality above 100 octane is long over-due. For what some industry spokesmen thought about a new scale of quality, see "What's Happening in Industry."

Keep Going to Page 250.

Advanced Planning

TAKE a look through "Meetings Calendar," to see what is coming up in the societies and associations of most interest to people in the petroleum-refining industry. A quick look now may make planning for trips easier in the months ahead.

Keep Going to Page 264.

The Fifth Man

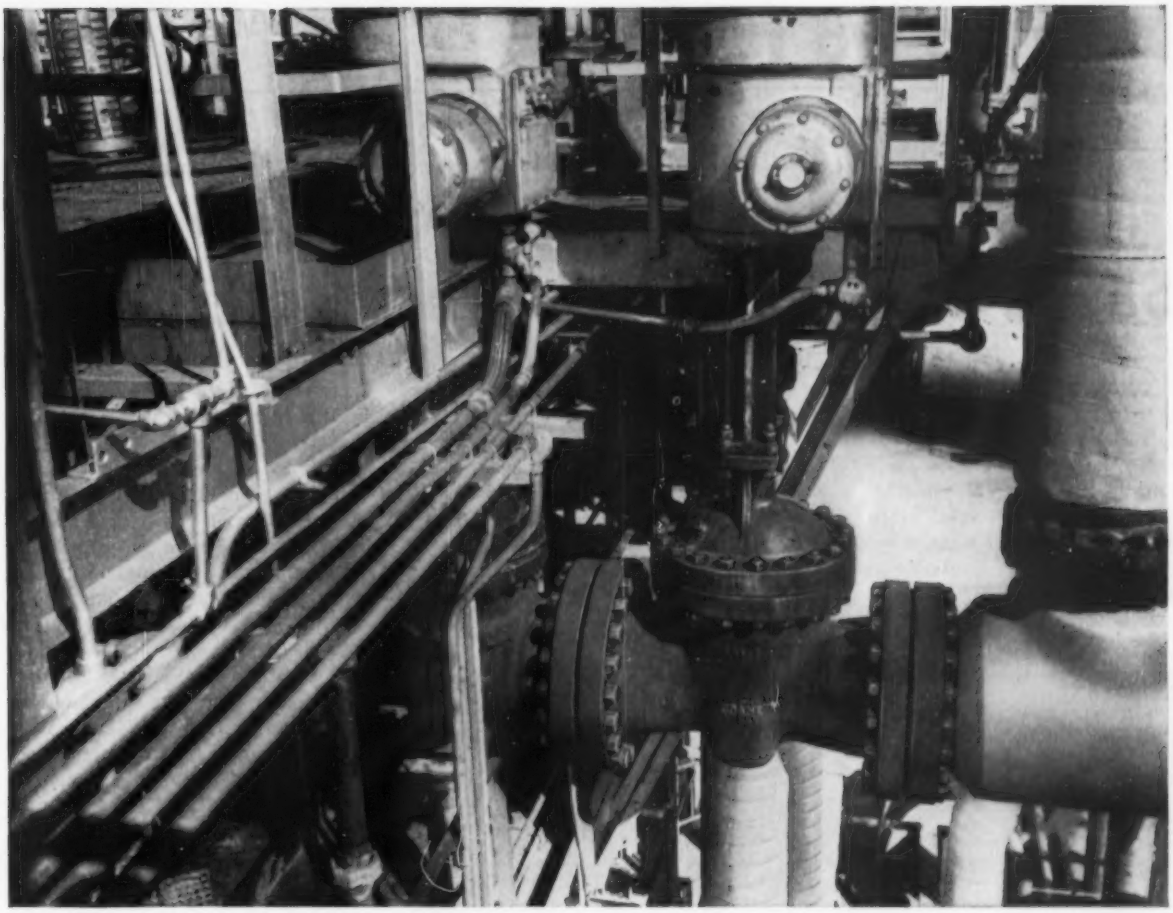
W. B. STROBEL, director of projects development in Continental Oil Company's Petrochemical department, has been selected to receive a Sloan Fellowship. The fellowship, which will give Strobel a year at Massachusetts Institute of Technology, is the fifth to be awarded to Conoco men in seven years. For that story, see "What's Happening Among Men in Industry."

Keep Going to Page 266.

New Developments

NEW DEVELOPMENTS in the companies which service and supply the refining-natural gasoline-petrochemical industry will be found in "What Suppliers are Doing." Interesting and useful information about the companies which serve your plant include changes in their personnel, extension of facilities, expanded services and changes in addresses.

Keep Going to Page 278.



Tight, easy closure after 15 years on hot gas up to 1030° F.—with Crane valve

THE CASE HISTORY—Installed in a leading Southwest oil refinery, this Crane valve is beating its own record every day.

Since 1941, this 12 x 18-inch venturi 600-pound cast steel gate valve —with flexible wedge disc—has handled hot gas on an inlet line, from 900° F. to 1030° F. at 240 pounds pressure. It is motor-operated on a 6- to 8-hour cycle.

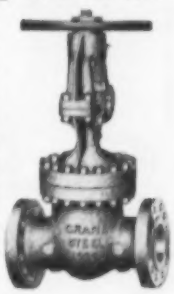
During the 15 years on this severe service, the *only* maintenance given this Crane valve has been routine during the scheduled unit shutdowns. The valve remains leak-free and continues to operate smoothly, with no repairs whatever to date.

This efficient flow-control operation is but one among thousands performed by Crane valves in oil refinery service—thousands of cases where Crane dependability has saved countless maintenance dollars and production time. What's back of such performance? *Proven* design—*proven* quality of materials —backed by more than a century's experience in valve development and manufacturing.

Don't take chances with your all-important valves—specify Crane to be sure of efficient performance.

Crane meets your every need in refinery valves—gates, globes, angles or checks—with screwed, flanged or welding ends—in sizes up to 24 inches—in pressure classes up to 2500 psi.

Call your local Crane Representative for valuable help in specifying and ordering, or write to address below.



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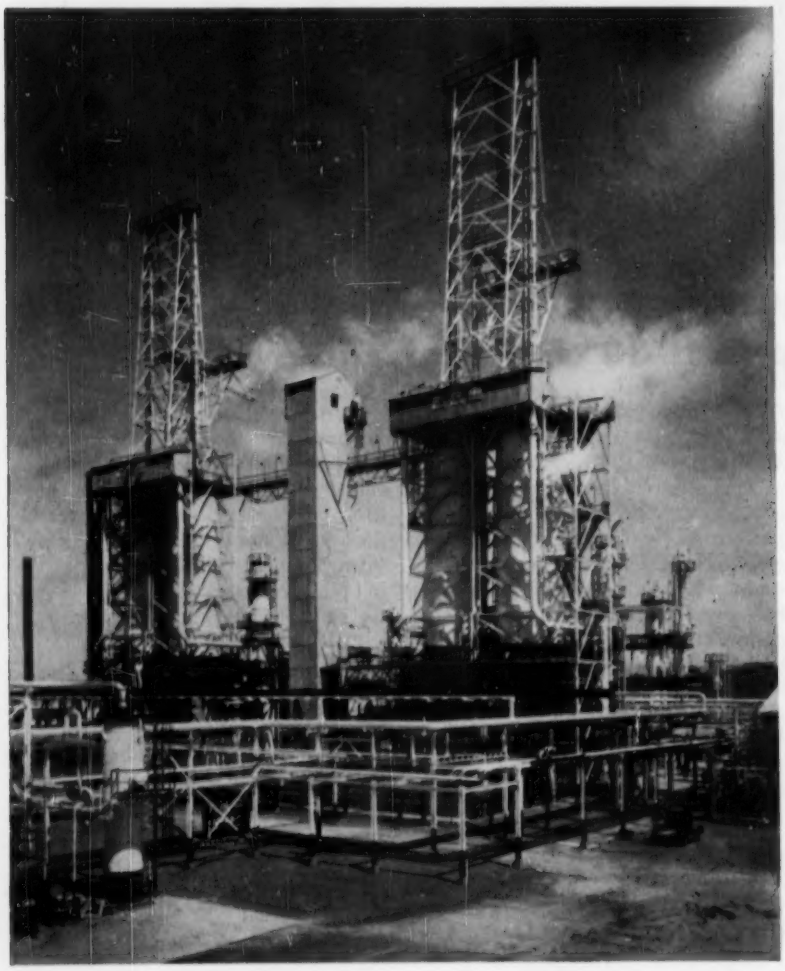
Save Money in Field Stress Relief

One Construction firm recently saved almost 12,000 square feet of insulation on a stress relieving job by using the same insulation for each of four large vessels. Normally, when there is only one vessel to be stress relieved, lower cost mineral wool felt can be used as the insulating material and thrown away after use. In this case however, in order that the same insulating material might be used on each coke drum with a minimum of waste, mineral wool blankets capable of withstanding higher temperatures and much more handling were used.

"In-place" stress relief of completely fabricated components such as the huge vessels used in the chemical and pertoleum processing industries, is accomplished by creating a furnace of the structure itself. Large portable oil-fired burners, capable of delivering up to 40,000,000 Btu per hour, fire directly into the vessel to bring it up to critical temperature. To help establish and maintain the critical temperature within the required time limits, high temperature thermal insulation, conforming to rigid specifications, prevents excessive heat loss to the outside atmosphere.



These four large coke drums were stress relieved in place.

In a typical operation, the stress relief of four coke drums already fabricated and erected at a large West Coast oil refinery, spun mineral wool blankets helped maintain the temperature of the vessels at 1200 F. minimum—with a maximum variation of less than 150 F. as required by the ASME code.

Each of the four vessels was heat-treated in turn. Reinforced on one side by expanded metal lath and on the other by 1-inch wire mesh, the mineral wool blankets not only satisfactorily limited heat loss at the high temperatures involved, but also withstood the eight handling operations, with exceptionally little mechanical failure. Fewer than 5000 square feet of the 4-inch blankets were required to insulate all four of the vessels, each of which had a surface area of approximately 4200 square feet.

Eighteen feet in diameter and nearly 75 feet tall, the drums constructed of ASTM A-204 plate lined with 7/64-inch ASTM A-240 (Type 405), were mounted on concrete platforms 30 feet above grade. The insulating blankets were secured to their exterior surface by ¾-inch stainless steel bands. These bands were of expander strap to allow for thermal expansion of the vessels. Asbestos paper, installed on the outside of the blankets under the steel strapping, protected the insulation from rain and wind for the relatively short period of time they were in place. Spun mineral wool felt, 4

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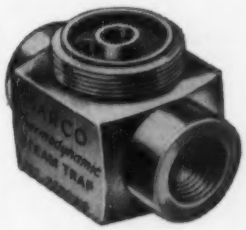

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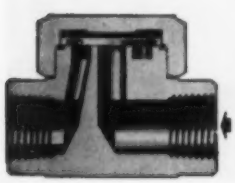

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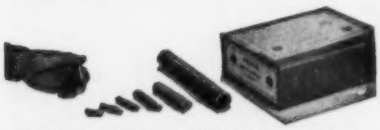

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How to Do It . . .

inches thick and 4 pounds density, was used to fill in around vessel outlets.

Stress relief of each vessel was performed under varying weather conditions. For example, when the first vessel was treated the ambient temperature was aproximately 70 F., whereas for another the ambient was slightly below 40 F. It rained during one test and, due to location on the sea coast, more than average wind was prevalent.

The specifications for this type of work called for insulation capable of preventing excessive radiation and convection losses at the normally high (up to 1400 F.) stress relieving temperatures. Blanket insulation was required to be of felted mineral fibers and be uniform in thickness and density. It could not fracture or dust excessively at 1400 F., the maximum temperature limit, and its thermal conductivity was to be less than .27 at 75 F. mean temperature, or .33 at 200 F.

Use a Rough Model In Planning Facilities

When one company was planning to add a warehouse at its refinery, the engineers built a rough model to show where drums of products would be handled and how trucks would be loaded from the stocks.

Short pieces of lath were tacked together to show the path drums would follow when being rolled out of the plant. A conveyor on the top showed how the drums were raised to the top level and then shunted off to the proper storage compartment.

The loading rack in back was then designed to show how trucks could be maneuvered with the simplest motions for loading drums.

If It Stinks—Beware

Natural gas delivered to many industrial users has no distinctive odor. To overcome the danger of undetected leaks, an odorant pot similar to the one shown here can be made from scrap pipe.

The idea is to put a plug in the top of the vessel, for checking the level and refilling the pot with ordorant. Another plug should be placed in the

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Petroleum REFINER is proud to reproduce this medallion as a salute to the A. Y. McDonald Manufacturing Company on the occasion of their 100th Anniversary. The sustained growth of this company and the worldwide industry acceptance of their products truly represents Stability.

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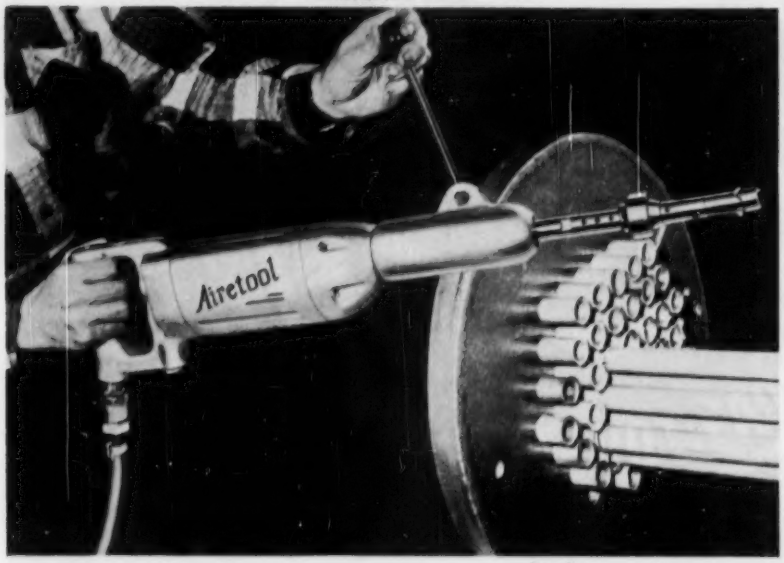

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How to Do It...

riser from the pot, for adjusting the wick. The wick can be made from a piece of sash rope.

In this installation, gas flow is from right to left with the odorizer mounted on the low-pressure side of the regulator. Valves for by-passing and a safety valve complete the installation.

Crows Nest Aids Relief Valve Inspection

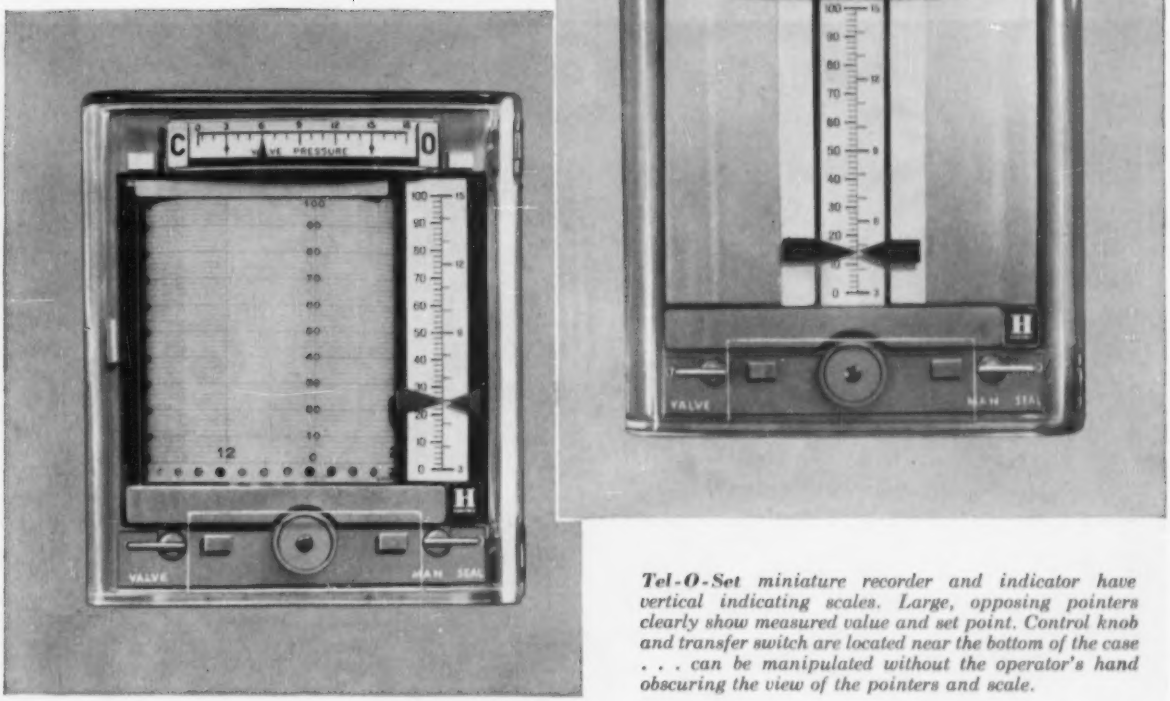
Relief valves located outside refinery areas are not always easily accessible for inspection and testing.

One operator has solved this problem by welding a platform at the top of the riser pipe used for a support. Short pieces of ¾-inch rod, welded to the riser, form a ladder for access to the crow's nest. The valve is fitted with a cover to keep out rain and dirt.

With this arrangement, periodic checks and adjustments can be made without worrying about ladders or scaffolds.

Your Ideas are Valuable!

At least $10 will be paid for each idea accepted for "How to Do It." Just send a brief note with a photo or sketch to the Editor, *Petroleum Refiner*, P. O. Box 2608, Houston.



Tel-O-Set miniature recorder and indicator have vertical indicating scales. Large, opposing pointers clearly show measured value and set point. Control knob and transfer switch are located near the bottom of the case . . . can be manipulated without the operator's hand obscuring the view of the pointers and scale.

Design your instrumentation

for simplest installation, startup, service

with *Tel-O-Set* miniature instruments

Easy installation. The indicating and recording chassis can be supplied separate from the case. The case contains the valve pressure gage and pressure regulator. Install it in your panel, make complete piping connections . . . then insert the chassis later, at startup.

Foolproof startup. Shipped separately, the chassis is protected against dirt and damage until startup. Air lines can be checked, control valves stroked and final inspection made *before* the chassis and controller are installed.

Serviced in seconds . . . that's all it takes to replace a complete chassis. No loss of control during replacement . . . no electrical connections disturbed. To adjust zero and span, or to inspect parts, you can partly withdraw the chassis from the case without interrupting operation.

Tel-O-Set instruments are applicable to temperature, pressure, flow and liquid level. They work with any pneumatic force-balance controller. They are sensitive, accurate . . . have true linear calibration . . . respond instantly. Call your local Honeywell sales engineer for a discussion . . . he's as near as your phone.

MINNEAPOLIS-HONEYWELL REGULATOR CO., *Industrial Division*, Wayne and Windrim Avenues, Philadelphia 44, Pa.—in Canada, Toronto 17, Ontario.

MINNEAPOLIS **Honeywell**

BROWN INSTRUMENTS

First in Controls

Who's Building . . .

Next Construction Boxscore will appear in the July issue.

Combustion section of turbo-prop engine undergoes test at Beacon, N. Y.

New Texaco Laboratory Devoted to Jet Fuels

THE TEXAS COMPANY has opened the U. S's first privately financed jet-fuels laboratory.

At the company's principal research center at Beacon, N. Y., the new $250,000 installation is expected to step up Texaco's development of fuels for all turbine engines, ranging from supersonic giants with 10-ton thrusts to the lightweight turbines being developed for passenger cars.

The new laboratory, which took a year to complete, is believed to be the first company-financed installation in the petroleum industry capable of testing jet fuels in full-scale combustors. This "full-scale" approach will permit highly accurate reproduction of actual operating conditions.

Design of the new building and the test apparatus is based on experience gained in developing jet fuels in several earlier Texaco laboratories. Equipment consists of three air compressors with a total horsepower of 1800, a gas-fired air heater, test stands for three full-scale aircraft gas-turbine burners, special exhaust silencers and the associated controls and instruments needed to carry out tests and record data.

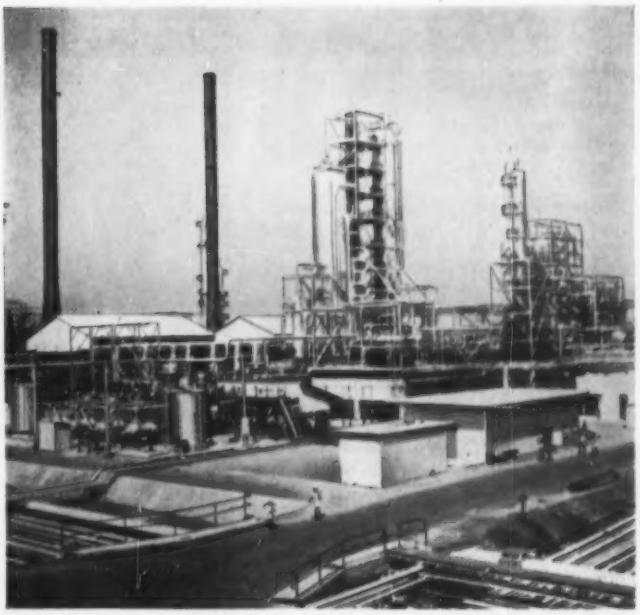
These new facilities will make it possible to conduct combustion studies over practically the entire range of conditions encountered in air-breathing jet type power plants.

Air entering the three-stage compressor can be compressed to the equivalent of 20 atmospheres. This is sufficient to duplicate aircraft gas turbine operating conditions of flight speeds in excess of 1000 mph and altitudes of as much as 100,000 feet.

The gas-fired air heater reproduces the heat found at the jet engine's burner input during the foregoing flight conditions. The heater can gen-

difficult physical conditions, but...

India's largest refinery was completed a year ahead of schedule



The 40,000 B/D refinery of Burmah-Shell Refineries Ltd. near Bombay, India is the country's largest. It is capable of supplying an estimated half of India's current requirements for finished petroleum. Although built in the face of difficult physical conditions, close cooperation with the owner in planning and engineering, and exceptional coordination of construction allowed Lummus to finish almost a year ahead of the original schedule.

A smoothly running refinery now, consisting primarily of crude distillation, fluid catalytic cracking, gas recovery, treating and blending units, offsite facilities and utilities, at the start it was only 450 acres of incredibly difficult terrain, without roads, railway or harbor.

Battling two of Bombay's worst monsoons, Lummus employed as many as 14,000 Indians at peak periods. Terrain was filled and drained. Roads, rail lines, harbor facilities, and the complete refinery were constructed. The job was kept moving *ahead* of the timetable – and finished 21 months from the start of construction.

A project of this magnitude requires a worldwide organization of experienced engineers and construction men able to cope with any problem. Lummus is such an organization and can design and build your next plant whatever the size, type or location.

The Lummus Company, 385 Madison Avenue, New York 17, New York. *Engineering and Sales Offices:* New York, Houston, Montreal, London, Paris, The Hague, Bombay. *Sales Offices:* Chicago, Caracas. *Heat Exchanger Plant:* Honesdale, Pennsylvania. *Fabricated Piping Plant:* East Chicago, Indiana.

LUMMUS

ENGINEERS AND CONSTRUCTORS FOR INDUSTRY

For more data on advertised products, use Readers' Service Cards, last page.

Who's Building . . .

erate up to 3,000,000 BTU's per hour.

The actual test area in the new two-story building consists of two test cells. One is for high-pressure testing and has one combustor test stand. The other is for medium pressure and vacuum testing. The latter is presently equipped for one burner stand. However, it has piping, controls, and instrumentation for another burner installation.

Two-story-tall exhaust silencers outside the laboratory building reduce the noise from the burner tests to a level comparable to that of the ordinary sounds in the test area. Two smaller silencers dampen noise from associated equipment.

Mitsui Petrochemical Industries, Ltd., will build Japan's first major petrochemical plant, a $30-million installation for the production of chemical intermediates to be used in the manufacture of synthetic textiles.

The plant, to be built at Iwakuni City, is scheduled for completion in November 1957. Scientific Design Company, Inc., will design and engineer plant units.

In the initial phase of its operation, the plant will turn out ethylene oxide, ethylene glycol and cumene. Later, facilities will be added for the manufacture of dimethyl terephthalate.

Borden Company has a new formaldehyde and synthetic-resin plant planned for Fayetteville, N. C. Scheduled for completion late in 1956, the plant will complete a Borden chain of East Coast formaldehyde plants. Designs call for an stallation turning out 36 million pounds a year.

Elk Refining Company has gone on stream with a new Unifining unit designed to operate on a block-off basis as a feed-preparation unit for the Platformer at its Falling Rock, W. Va., refinery.

The new 1000-barrel-a-day unit, built by refinery personnel, is pretreating thermally-cracked gasoline to prepare additional feed stock for the Platformer, which has been in operation since 1952. In the other phase of the unit's operation, regular kerosine and naphthas are being upgraded.

The Standard Oil Company (Ohio), assisted by The M. W. Kellogg Company, has completed preliminary engineering studies for new refinery facilities to be built in 1957 at Toledo. Additions to the Sohio plant there are expected to cost between $35 and $40 million.

Kellogg will start immediately on detailed engineering plans and on ordering equipment for the project. It will be the largest ever undertaken by The Standard Oil Company (Ohio).

Late in 1956 work will be started on clearing the site at the Toledo refinery. Construction is to begin early in the spring, with the new facilities due to be completed in December 1957.

United Carbon Company, Inc., will take part in constructing a $6-million carbonblack plant near Melbourne, Australia. The new plant will be built and owned jointly with Shell Chemical (Australia) Proprietary, Ltd., which operates a refinery near the projected site.

Sohio Chemical Company, organized by The Standard Oil Company (Ohio) to operate its new $18-million petrochemical plant at Lima, Ohio, has gone on stream with the plant's 120-tons-a-day urea plant.

The urea unit, first of its kind to be built in the U. S., uses the Swiss Inventa process developed by Holzverzuckerungs, A. G. (Hovag) of Ems, Switzerland, an affiliate of Inventa, A. G., of Lucerne.

Also in operation is Sohio's new 100-ton-a-day dry-ice plant, recently completed at a cost of some $800,000. Sohio has been turning out anhydrous ammonia, nitric acid and nitrogen solutions at Lima since early this year.

Vulcan Engineering division of The Vulcan Copper & Supply Company, which holds the licenses and rights for the U. S. and Canada on the Inventa Process, was prime contractor on the job, and Arthur G. McKee & Company was the constructor.

United Refining Company has awarded the contract for more than $2 million worth of new construction at its Warren, Pa., refinery. The project, to be handled by Procon, Inc., will include construction of a 2500-barrel-a-day fluid catalytic-cracking unit and gas-recovery facilities, a catalytic-polymerization unit and light-hydrocarbon and gasoline treating equipment. Work will start in June and completion is expected by the end of the third quarter.

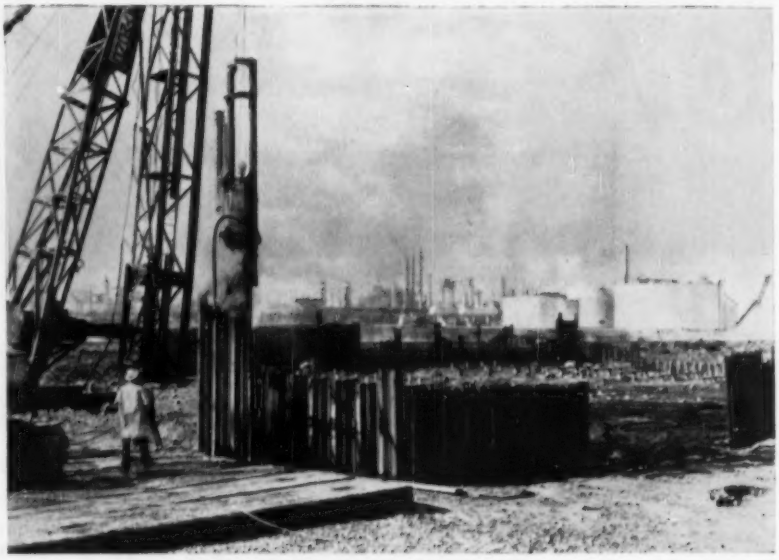
Government of Iraq is planning to expand its Daura refinery, near Baghdad, reaching for a daily capacity of 30,000 barrels by early 1957 and 40,000 barrels by 1960.

The refinery, which went on stream in mid-1955 with a capacity of 24,000 barrels a day, has been operating at a peak near 27,000 barrels.

Kerr-McGee Oil Industries, Inc., has engaged C. F. Braun & Company to study the 20,000-barrel-a-day Cushing, Okla., refinery it plans to buy from General American Oil Company and determine what is needed to raise the octane of gasoline manufactured there. (See "What's Happening.")

Jordan Government is considering construction of the country's first refinery at El-Zarka, near Amman. The plant, to have a daily crude capacity of 5000 barrels would fill domestic demand for gasoline fuel oil and asphalt. It planned for the refinery to go on stream during 1958.

Regent Oil Company, a British marketing concern will enter the refining field with a 40,000-barrel-a-day plant to be built somewhere in southern England. Construction will be started during 1956 with the $51-million refinery due to go a stream in 1958. Later it will be expanded to meet market needs.



Some 600 tons of temporary steel sheet-piling was used to build this "box" with a perimeter of 850 feet. The purpose was to provide a dry hole in which to construct a 12-foot deep concrete separator in Tide Water's expansion program at its Avon refinery.

Tide Water Associated Oil Company is building the world's largest fluid coker, as part of a major expansion program at its Avon refinery at Associated, Calif. The unit will be capable of converting 42,000 barrels a day of heavy fuel oil into gasoline and diesel-oil components for further treatment.

As part of the project, Tide Water erected a separator in a marshy section of the refinery. This area was overlaid with 15 to 20 feet of saturated mud and decayed organic matter, below which was a close-packed clay.

To provide a dry hole in which to construct the 12-foot deep concrete separator, Bechtel Corporation, design engineers and constructors for the project, rented about 600 tons of temporary steel sheet piling, and drove a sheet-piling box of 850-feet perimeter.

Construction of the separator was carried on within the sheet-piling wall, dry throughout a wet winter.

In addition to the fluid coking unit, Tide Water's expansion includes an 88-Mmcf.-a-day gas plant, a hydrodesulfurization unit, modifications and expansion of an existing fluid catalytic-cracking unit, and off-plot and interconnecting facilities to accommodate them.

CONDENSER TUBE CLINIC

Edited by Arthur W. Tracy,
Metallurgical Engineer,
The American Brass Company,
Waterbury, Connecticut

25 Years' Experience has proved the Value of Arsenic as an Inhibitor

Research at The American Brass Company nearly a quarter of a century ago showed that about 0.04% arsenic would inhibit dezincification of brass, and this amount of the element has been added to Admiralty metal and aluminum brass since then.

Inland power stations find that ANACONDA Arsenical Admiralty-439 serves well under normal water conditions, its arsenic content effectively inhibiting dezincification.

Tidewater power stations must contend with much more corrosive waters, and ANACONDA Ambraloy-927, the arsenical aluminum brass, is preferred because it is not only resistant to dezincification but also to impingement or erosion pitting by either clean or polluted sea waters flowing at relatively high velocities.

Oil refineries have virtually made ANACONDA Arsenical Admiralty-439 standard for refinery condensers and heat exchangers handling crudes, rerun stocks, cracked products, lubricating oils, and by-products. It is resistant to dezincification and can handle corrosive cooling waters at relatively high temperatures. Another important property is its ability to withstand attack by sulfur compounds resulting from the refining of sour crudes. ANACONDA Ambraloy-927, because of its resistance to dezincification and to pitting corrosion by sea water at relatively high velocities, is sometimes preferred in oil refineries on tidewater.

Marine users generally find ANACONDA Arsenical Admiralty-439 satisfactory for inland-water vessels and also for seagoing vessels where service conditions are moderate; but ANACONDA Ambraloy-927 is preferred for most seagoing vessels. Both alloys are resistant to dezincification under all corrosive conditions found in these services.

Your own needs may call for these corrosion-resistant Anaconda alloys or they may call for other tube alloys we make. Our Technical Department will be glad to help you select the one best alloy for the conditions you face.

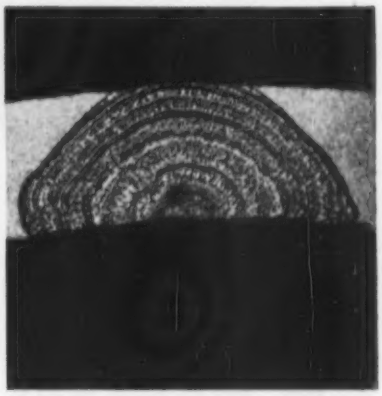
Technical Service—Get full information on our technical services and products by writing The American Brass Company, Waterbury 20, Connecticut. In Canada: Anaconda American Brass Ltd., New Toronto, Ont. 6478

APPROXIMATE MECHANICAL AND PHYSICAL PROPERTIES
(Light Annealed Tubes)

	Arsenical Admiralty-439	Ambraloy-927
Tensile Strength, psi.	52,000	60,000
Yield Strength, 0.5% Elongation, psi.	22,000	27,000
Elongation in 2", %	60	55
Rockwell Hardness "B"	6-45	35-65
Density, Lb./cu. in.	0.308	0.301
Thermal Conductivity, B.T.U./Sq. Ft./In./Hr./°F. at 68°F.	768	696
Coefficient of Linear Expansion, Average per °F. (77°-572°F.)	0.0000112	0.0000108

TWO TYPES OF DEZINCIFICATION IN NONARSENICAL CONDENSER TUBES

(approx. 120X)
LAYER-TYPE DEZINCIFICATION on the inner wall of an uninhibited Admiralty metal tube from an oil refinery using polluted fresh water.

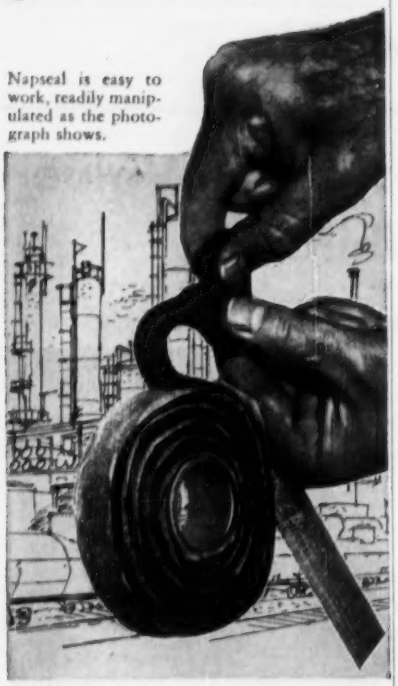


(approx. 17X)
PLUG-TYPE DEZINCIFICATION on the inner wall of an uninhibited Admiralty metal condenser tube from a power plant operating on tidewater.

ANACONDA®
Tubes and Plates for Condensers and Heat Exchangers

For more data on advertised products, use Readers' Service Cards, last page.

NEW
sealing compound resists gasoline and oil...



Napseal is easy to work, readily manipulated as the photograph shows.

J-M NAPSEAL

Napseal is the compound for those difficult sealing jobs where exposure to oils and fuels (including aviation gasoline) is encountered. Highly adhesive, it holds a tight seal, remaining permanently plastic in the presence of petroleum derivatives. Napseal retains its water tightness, will not dry out in service.

Napseal is easy to work and remains workable over a wide temperature range. It will not corrode metals or cause the deterioration of common substances in contact. Neither will it stain.

Napseal is handy for emergencies and other sealing needs. It requires no mixing, comes ready to use in beads, ribbons and 3″ diameter pugs. Data sheet EL-64A gives more information. Write Johns-Manville, Box 60, New York 16, N. Y. In Canada, Port Credit, Ontario.

JM

Johns-Manville
SEALING COMPOUNDS

Who's Building...

of an existing fluid catalytic-cracking unit, and off-plot and interconnecting facilities to accommodate them.

Empire Petroleum Company is completing a new vacuum unit at its Sheboygan, Wis., refinery. The new unit will boost plant capacity from 5000 barrels a day to 8000.

Gulf Oil Corporation will double the sulfur-recovery capacity of its Port Arthur refinery, expand its polymerization, alkylation and acid-sludge facilities, and build a new packaging and grease plant.

For its refinery at Philadelphia, where a $35-million expansion and modernization program already has been scheduled, Gulf will build two new catalytic-reforming units, instead of the one previously announced. Each of the reformers will be built for a daily capacity of 26,000 barrels.

When the new reformers are completed at Philadelphia in 1957, essentially all the refinery's gasoline components will be catalytic. The new units will pass straight-run gasoline over platinum catalyst together with hydrogen to give the company a higher-octane product.

The two units, both Platformers designed by Universal Oil Products Company, will be built by Procon, Inc.

The new packing and grease plant at Port Arthur will include offices and two new tank farms. It is scheduled for completion in the fall of 1957.

Duplication of a unit put on stream at Port Arthur in 1952 and now extracting 140,000 pounds a day of sulfur from off-

Mobile Crane Used at Watson

One of the largest mobile cranes in Southern California was used in the construction of a catalytic-reforming unit now nearing completion at the Watson refinery of Richfield Oil Corporation.

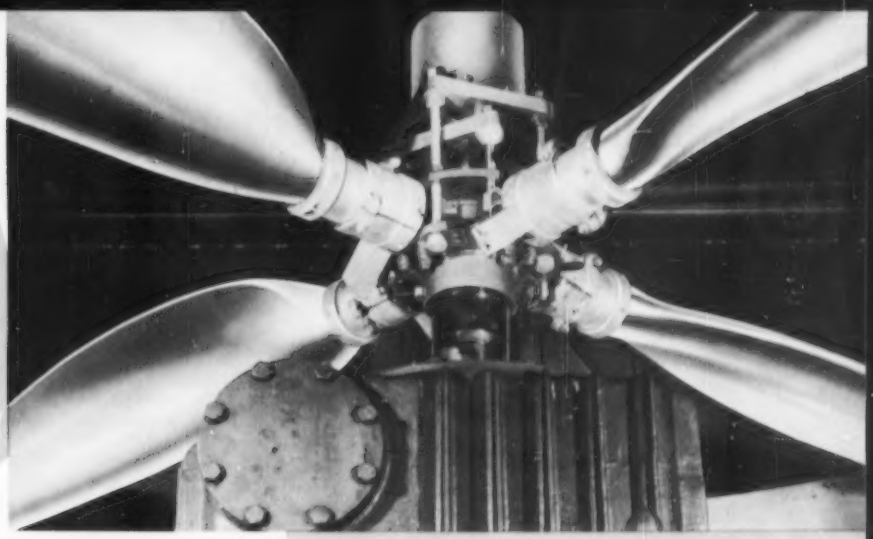
A 109-ton pressure vessel was set in place by the crane to become part of the refinery's new 17,000-barrel-a-day reformer.

This was believed to be the first time such a crane, weighing 170 tons, had been used to lift and place such a large vessel in a refinery area. The lift was accomplished by using an 87-foot boom to bring the vessel from a prone ground-level position to a final vertical position on top of a foundation 30-feet high.

The high-pressure vessel, a hydrogeneration reactor, will be used to remove sulfur compounds from the feed stock to the catalytic reformer, and among other things eliminate discharge of pollutants to the atmosphere.

The catalytic-reformer project for Richfield was started by The Ralph M. Parsons Company in October 1955 and is due for completion this month.

for peak heat exchanger efficiency



hold fluid outlet temperature to ± 1½° F ...cut power costs by up to 50% with the Hartzell Controllable Pitch Fan

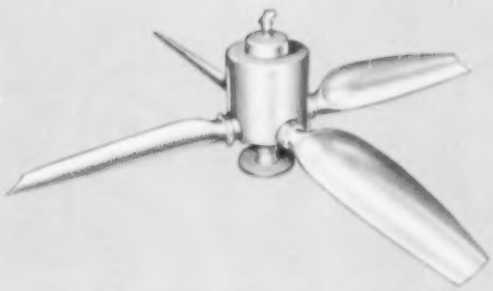
The Hartzell Controllable Pitch Fan meets a long-standing need in the petroleum industry for a precise, relatively fool-proof method of controlling a variable flow of air to maintain predetermined temperatures. These new fans will hold outlet temperature fluctuations to plus or minus 1½° F. when connected to an adequate temperature-sensitive control system. And, while achieving this highly accurate level of control, they consume up to 50% less power than conventional fixed-pitch fans.

Variable air delivery is accomplished by variation in blade pitch setting. The fan assembly responds instantly and automatically to conventional control equipment—increasing blade pitch to deliver more air when outlet temperature rises, decreasing blade pitch and delivering less air when outlet temperature falls.

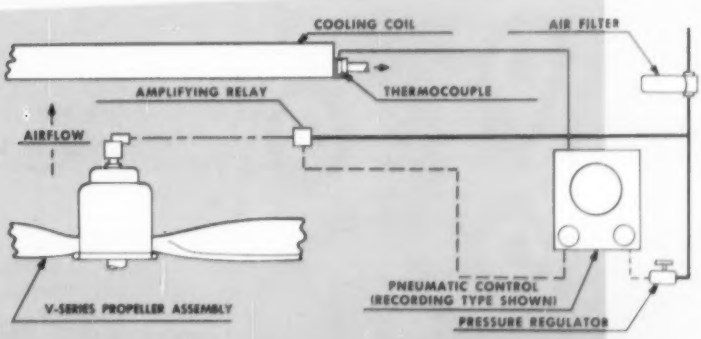
This pitch change technique, and the Hartzell pitch change mechanism, are highly adaptable to precision control. The mechanism is so sensitive that a cloud passing over the sun is often enough to produce a minor blade pitch adjustment.

The design of the Hartzell Controllable Pitch Fan is based on the same principal used on the Hartzell constant speed, full feathering propellers which are now used on all light twin engine airplanes. In fact, many of the same parts are used. The ball-bearing and clamp blade retention mechanism has proved an unqualified success in ten years of aviation service. Another carry-over from the aircraft propeller is the exceptionally heavy torque tube which easily withstands the heavy torque and bending loads common to heat exchanger installations.

The Hartzell Controllable Pitch Fan is available in 144", 132" and 120" diameters with Hartzite plastic blades or 120", 103" and 96" diameters with cast aluminum alloy blades.



The photo at the top of the page shows a Hartzell Controllable Pitch Fan with Hartzite plastic blades installed on a speed reducer. Cylinder cover has been removed to show push plate and rods which respond to changes in air pressure in the control system to produce changes in blade pitch. The view immediately above shows an aluminum fan assembly with cylinder cover in position.



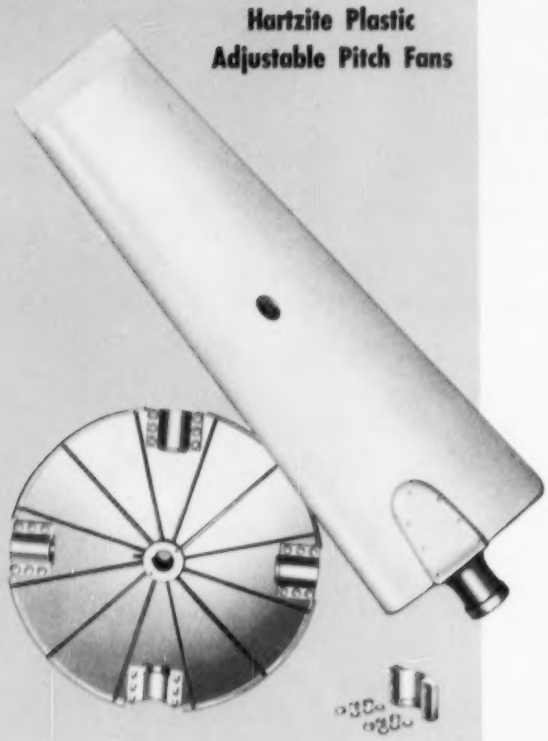
Typical Control Diagram—Hartzell Controllable Pitch Fan

- **For complete details on this amazing fan, send the coupon on the next page or call your nearby Hartzell field engineer.**

- **See the opposite side of this sheet for information on the petroleum industry's preferred line of adjustable pitch cooling tower and heat exchanger fans.**

Hartzell adjustable-pitch cooling tower and heat exchanger fans practically eliminate problems of fan failure

Hartzite Plastic Adjustable Pitch Fans



Phenolic-impregnated, fabric-base Hartzite plastic offers exceptional resistance to vibration, corrosion and mechanical damage. And if the surface of the blade should be damaged, the interior offers the same high strength and resistance.

Strength and rigidity are insured by the tapered blade design and the use of a heavily-reinforced leading edge. The built-up leading edge also gives the blade a tear-drop cross section which produces top efficiency by smoothing out the flow of air over the blade.

Hubs used with these blades have an extremely high safety factor. All hubs are dynamically balanced and all blades balanced against a master blade. Blade pitch adjustment, to change air delivery, is easily made with a protractor.

SPECIFICATIONS

DIAMETERS: 10′, 11′, 12′, 13′, 14′, 16′, 18′, 20′, 22′

ASSEMBLIES: 2 blade, 3 blade, 4 blade and 6 blade

BLADES: Phenolic-impregnated, fabric-base Hartzite plastic, molded to shape

HUB: Thick steel plate with steel gussets and lower blade clamps welded on; malleable iron upper blade clamp held by 4 or 6 heat-treated bolts

All-Aluminum Adjustable Pitch Fans

Both hub and blades on these fans are sturdy, corrosion-resistant aluminum alloy castings. Blade housings in the hub are threaded to admit threaded blade shanks. Blade pitch adjustment, to meet changing air delivery needs, is made by simply loosening two bolts on each blade socket.

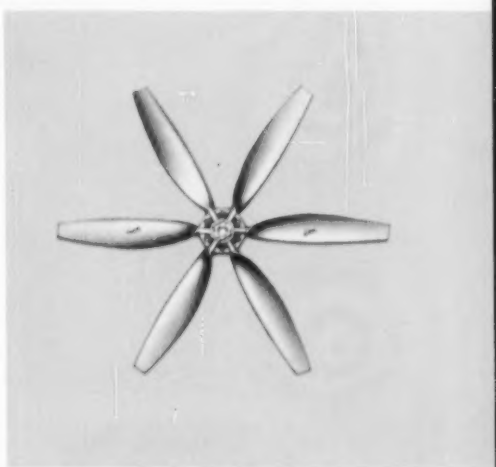
Because all hubs are dynamically balanced and all blades balanced against a master blade, damaged blades can be replaced in the field without destroying balance of the assembly.

SPECIFICATIONS

FAN DIAMETERS: 40″, 44″, 53½″, 60″, 72″, 85″, 96″, 103″, 120″, 132″

ASSEMBLIES: 3 blade, 4 blade and 6 blade

MATERIAL: Cast aluminum alloy



HARTZELL PROPELLER FAN CO.
910 Herrman Ave., Piqua, Ohio

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HARTZELL
propeller fan co.
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ENGINEERING OFFICES IN PRINCIPAL CITIES

Who's Building...

gases will make the refinery there self-sufficient in that element. It also is expected to provide Gulf with a surplus.

Addition of six reactors will increase capacity of the Port Arthur refinery's polymerization unit to about 5000 barrels a day; capacity of an alkylation unit will be stepped up from 1200 barrels a day to about 4000, and four new acid-sludge decomposing units will be added to give the refinery a total of six.

Petroleos Mexicanos will build a $2.5-million refinery at Ciudad Pemex in Vera Cruz. The plant is due to go on stream in 1956.

Arkansas Fuel Oil Corporation is completing a 900-barrel-a-day catalytic-reforming unit at its natural-gasoline plant near Carthage, Texas.

The new unit, a Platformer licensed by Universal Oil Products Company, is expected to increase the octane rating of gasoline produced at Carthage by 16 points. The plant's leaded gasoline which did have an octane rating of 82 will have a rating of 98, with the same amount of lead added. Isopentane also will be produced with the newly-added facility.

Sunray Mid-Continent Oil Company is operating a new gas-products plant near Ingleside, Texas, designed to handle 220 Mmcf. of natural gas a day. Since the plant went into operation, it has been processing 180-190 Mmcf. of gas, with liquid recovery running about 110,000 gallons a day. In addition to natural gasoline, the new facility is turning out propane, butane and isobutane.

Shell Oil Company has gone on stream with a new major addition to its Houston refinery. The refinery's second Platformer, the new unit can produce 16,000 barrels a day of high-quality gasoline components.

It is operating on a higher-boiling charge than the first unit, with feeds from sour setocks being processed through a new desulfurization unit to protect the platinum catalyst from contamination.

This auxiliary unit operates like a Platformer, except that it uses cobalt-molybdenum rather than platinum as a catalyst.

Panhandle Oil Corporation will start work on a catalytic-reforming unit for its refinery at Wichita Falls, Texas. Planned later are improvements to the refinery's existing plants.

Estimated cost of building the reformer is $750,000. It will be a Platforming unit, licensed by Universal Oil Products Company.

Installation of the new unit will double Panhandle's output of high-quality gasoline, enabling it to increase its processing of crude from 7000 to 8000 barrels a day.

Societe Naphtachimie, increasing capacity of its petrochemical plant in the Marseilles area, will convert facilities to use either a light-naphtha or gasoline feedstock.

The project is raising the plant's ethylene capacity from 10,000 to 18,000 tons a year, increasing its 8000-ton ethylene-oxide capacity by two fold, and doubling propyl-

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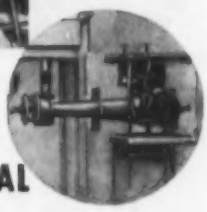
785 East 144th St., N. Y. 54, N. Y.

VERTICAL



OR HORIZONTAL

many more hours on stream without forced shutdown with NATIONAL AIROIL

OIL-GAS TANDEM COMBUSTION UNITS

Exclusively for vertical firing, the new National Airoil VERTICAL Tandem Block Units retain all the features of our regular horizontal Tandem Units . . . **plus:** special, precast refractory shapes for easier, cost-saving vertical installation and maintenance; secondary air inlet louvres for positive control of vertical flame pattern; and, all steel duplex detaching gear which enables swift, simple vertical burner change-over.

VERTICAL and HORIZONTAL Tandem Units hold air in the combustion zone until fuel and heated air are thoroughly mixed. This means that ignition takes place in a hot zone; the result: high fuel economy through more rapid combustion with a minimum of excess air. NATIONAL AIROIL's patented Tandem Combustion Units allow secondary air to be easily and accurately controlled. By adjusting air control louvres, flame can be shaped to radiate heat uniformly without tube impingement.

The VERTICAL or HORIZONTAL Tandem Unit is always fired with NATIONAL AIROIL Combination Oil and Gas Burners . . . has a high turndown ratio with a steady flame temperature using either fuel oil or gas. With the TANDEM UNIT's clean flame, a cold furnace can be brought to full capacity in a short time.

"Many, many more hours on stream, without shutdown" . . . yes, YOU will realize higher profits from YOUR heaters when NATIONAL AIROIL VERTICAL or HORIZONTAL Tandem Units are specified. Our new Bulletin 498 is yours for the asking.

CHEMICAL-PETROLEUM DIVISION

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Southwestern Division
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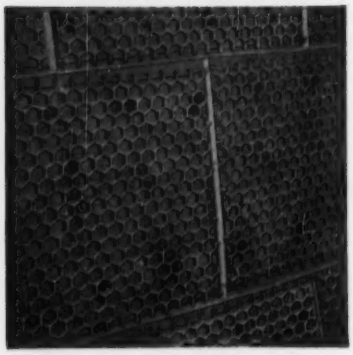
INDUSTRIAL OIL BURNERS, GAS BURNERS, AND FURNACE EQUIPMENT

RIGHT WHERE IT COUNTS!

IRVING "GRIDSTEEL" CONTOUR RETAINER MESH

Used with
Castable Ganister Linings
in Refractionating Units
in Petroleum
& Chemical Industries



RIGHT for
★ Thermal Cracking Units
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by using
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ESTABLISHED 1902

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Who's Building...

ene output to 18,000 tons. Some high-octane gasoline components also will be produced.

Feedstock for the plant comes from the nearby Lavera refinery of Societe Francaise des Petroles BP, which has a share interest in the Naphtachimie plant.

Ethyl Corporation will install facilities at its Baton Rouge plant to make vinyl chloride monomer from ethylene. Capacity of the plant was not announced.

Catalytic Construction Corporation was awarded the contract for engineering and construction. The project is due for completion late in 1957.

Esso Standard Oil Company has awarded the contract for construction of a 7200-barrel-a-day Powerforming unit at its Everett, Mass., refinery. Construction, by Badger Manufacturing Company, will be started shortly, with the unit expected to be on stream by mid-1957.

Two such units are in operation and 14 more are under construction, being designed or planned. The two on stream are at the Imperial Oil, Ltd., refinery at Edmonton and at the Esso Standard Oil Company's Baltimore refinery.

Big West Oil Company has started operation of a new catalytic-reforming unit at its refinery at Kevin, Mont. The unit, a 1000-barrel-a-day Platformer, will produce a 94-plus leaded octane blending component. Universal Oil Products Company designed, engineered and licensed the unit. Construction was handled by Procon, Inc.

Hancock Chemical Company, affiliated with Hancock Oil Company, is doubling the capacity of its 130-ton-a-day sulfur-recovery plant at Wilmington, Calif.

The plant recovers sulfur from hydrogen sulfide, stripped from waste recovery gases by use of monoethanolamine. Its output goes to plants operated by Richfield Oil Corporation. The Texas Company and General Petroleum Corporation.

The expansion, now in its early stages, is scheduled for completion in the fall. The Ralph M. Parsons Company is designer and builder.

Creole Petroleum Corporation is planning a third pipe still for its Amuay refinery and expansion of its LPG facilities. The company has one major LPG plant in operation, another being built and engineering studies under way on a third.

Societe Industrielle Belge des Petroles, S. A., is increasing the crude capacity of its Antwerp refinery from 58,000 to about 75,000 barrels a day. This work, which is due to be completed in 1956, will be followed in 1957 by additional expansion expected to raise capacity upward of 100,000 barrels a day. The company is an affiliate of Compagnie Financiere Belge des Petroles, S. A.

Erdol-Raffinerie Deurag-Nerag has gone on stream with a new Platformer and Unifiner at its refinery in Hannover.

The Unifiner, a 1400-barrel-a-day unit built to prepare feed stock for the Platformer, is processing a thermally-cracked stock boiling in the range of 250 to 400 F. The Platformer, with a design capacity of 3000 barrels a day, is processing heavy

COOPER ALLOY

CORPORATION BRIEFS

• Edited by GEORGE BLACK

DOUBLE-D REFINER

The Jones Double-D Refiner is said to bring an entirely new concept to the preparation of stock for the paper machine. Key to the design lies in the twin refining area with its double discs. For a more complete story ask for the February issue of Cooper Alloy NEWSCAST.

WHAT'S IN A TRADEMARK

Behind the Cooper Alloy trademark, cast or stamped into our stainless steel fittings, stands more than a quarter century of experience and the most complete production facilities in the industry. When you specify Cooper Alloy fittings you can be sure that every step from design to shipment is under the supervision of specialists. Look for the CA trademark before you buy . . . it is a sign of quality, experience and reliability.

DESIGN FEATURES FEATURED

Design features that have made the Cooper Alloy stainless steel valve the preferred valve for chemical processing are presented in the current issue of NEWSCAST. Diagrams and text combine to make a thorough presentation. Additional copies available on request.

NEW PUMP IN DEMAND

The new line of stainless steel rotary pumps announced by our Vanton Pump Division has taken the field by storm because it is the one (and only) pump of its kind without stuffing boxes or shaft seals. Bulletin VP561 gives the facts. Write for it today.

COOPER ALLOY
CORPORATION • HILLSIDE N J

5 Industries... Well-Known Companies

... typical of more than 100 companies for whom Grinnell is currently fabricating

POWER AND PROCESS PIPING

CHEMICALS
NATIONAL ANILINE DIVISION OF ALLIED CHEMICAL & DYE CORP., Hopewell, Va.

PULP & PAPER
UNION BAG & PAPER CORP., Savannah, Ga.

POWER
PENNSYLVANIA POWER & LIGHT COMPANY, Allentown, Pa.

BEVERAGE
CARLING BREWING COMPANY, Natick, Mass.

OIL REFINING
TIDEWATER OIL COMPANY, Delaware City, Del.

These successful companies, leaders in their respective fields, are building new facilities right now. The power and process piping needed in this construction is being fabricated in Grinnell shops.

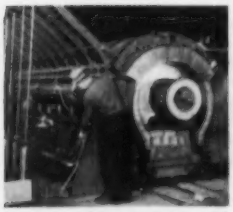
In fact, at this time — or at any given time, more than one hundred similar-type orders for prefabricated piping are being worked on by Grinnell. Why this marked preference by so many companies for Grinnell?

Because piping fabricated in Grinnell shops is done under ideal conditions, with modern equipment, by personnel qualified for each class of work. Included in the price (which is determined in advance) are such items of expense as: interpretive engineering, shop sketches and planning, procurement of materials, power services, expendable tools and supplies. All piping is rigidly inspected and tested to comply exactly with customer specifications and applicable codes. Consult Grinnell on your next piping job.

ATTENTION: *A 30-minute color sound film showing the quality and economy of Grinnell Shop Fabrication of all classes of piping is available for group showings.*

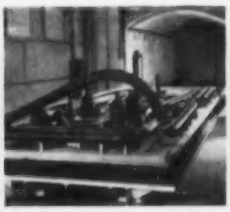
GRINNELL

WHENEVER PIPING IS INVOLVED



Pipe being heated to exact temperature required for proper bending

Skilled team completes bend in six minutes with pipe close to 2000°F



Fabricated piping, bending operation completed, enters stress-relieving furnace

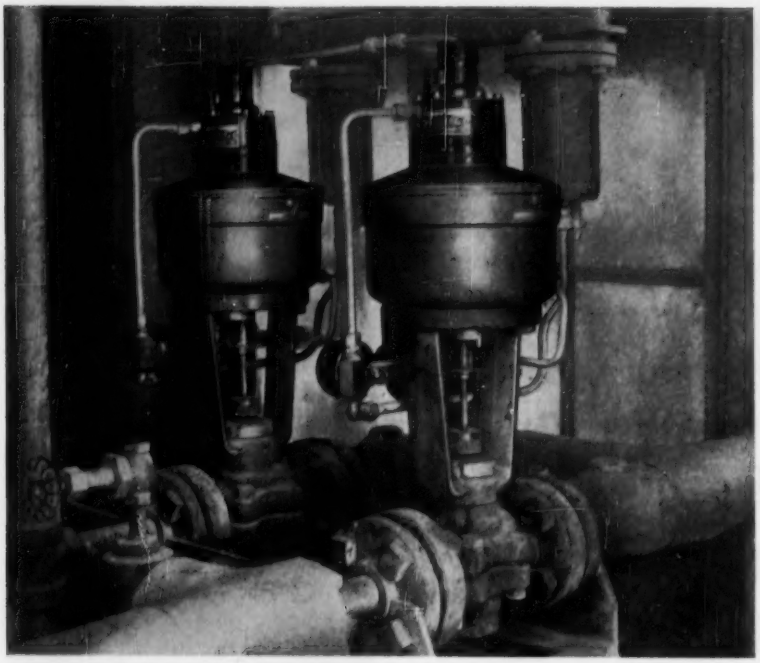
Heavy wall pipe being machined to the proper welding bevel on a post mill

Ultrasonic testing of a weld on heavy wall pipe

Grinnell Company, Inc., Providence, Rhode Island • Coast-to-Coast Network of Branch Warehouses and Distributors

pipe and tube fittings • welding fittings • engineered pipe hangers and supports • Thermolier unit heaters • valves
Grinnell-Saunders diaphragm valves • pipe • prefabricated piping • plumbing and heating specialties • water works supplies
industrial supplies • Grinnell automatic sprinkler fire protection systems • Amco air conditioning systems

For more data on advertised products, use Readers' Service Cards, last page.



600 to ONE CUSTOMER PROVES SATISFACTION...

THAT'S THE STORY BEHIND THESE CONOFLOW Series LB CONTROL VALVES

Photo shows an original installation of Conoflow Series LB Control Valves that has been on a temperature control application for several years. There are now over 300 of these valves in operation at this large manufacturing plant. By the end of the year there will be approximately 600 LB valves throughout the plant. Out of respect for our customer's company policy we cannot publish the name. However, the volume of valves involved proves that Conoflow Series LB Control Valves are eminently satisfactory to this prominent user.

The tandem operation shown is a typical application—cooling and heating—utilizing split ranges. One valve handles cold water with a 3-9 psi range. The other handles steam with a 9-15 psi range.

The revolutionary Cylinder Conomotor provides greater speed of response, tight shut-off and other performance characteristics superior to conventional valves. Downtime is practically nil compared with other valves.

Cono-Controls®
FOREMOST
IN FINAL CONTROL ELEMENTS

Catalog LB-1 tells the complete story of the benefits in Conoflow Series LB Control Valves. Write for your copy. Conoflow representatives are located in most principal cities.

CC-602

CONOFLOW CORPORATION
SUBSIDIARY OF WALWORTH COMPANY
2100 ARCH STREET • PHILADELPHIA 3, PA.

Who's Building...

straight-run naphtha and the product of the Unifiner. It was designed to produce 90 clear research octane blending component.

Both units were designed, engineered and licensed by Universal Oil Products Company.

Idemitsu Kosan Company has started construction on a 20,000-barrel-a-day refinery at the former naval depot at Tokuyama. Process units for the new Japanese refinery will be licensed by Universal Oil Products Company.

American Cyanamid Company has completed a 30-million-pound-a-year plant for the production of monomethyl styrene at Avondale, La.

The plant, the largest of its kind in the U. S., is the first phase of a $39 million expansion of the company's Fortier installation near Avondale. The new unit cost some $4.5 million.

Other expansion planned for Avondale includes duplication of several of the plant's present facilities to double the output of acrylonitrile. This work, to be taken up during the next five years, will cost about $25 million.

Also being considered are new facilities costing about $9.5 million to produce derivatives of acrylonitrile.

Bakelite de Mexico, a subsidiary of Union Carbide Company, has started production of phenol-formaldehyde resins at a $160,000 plant in Monterrey. The new plant has an annual capacity of 2 million pounds.

Phillips Chemical Company will build a sulfur plant in Andrews County, Texas, adjacent to a natural gasoline plant now under construction by the parent Phillips Petroleum Company.

Acid gas feedstock for the sulfur plant will come from the new gasoline plant. The plant, which will be completed this summer, is expected to produce about 60 long tons of sulfur a day.

Pacific Petroleum, Ltd., has plans for building a natural-gas absorption plant on the Peace River near Fort St. John, B. C. A contract for handling all phases of the $18-million project was awarded jointly to Stearns-Roger Engineering Company, Ltd., Calgary, Alba., affiliate of the U. S. concern, and Marwell Construction Company, Ltd., a Vancouver firm.

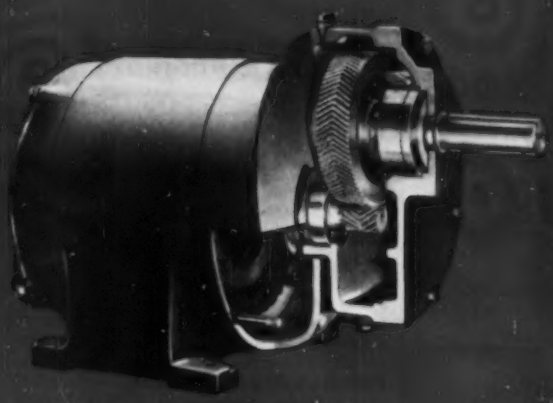
The plant will be a three-phase operation, turning out gasoline, propane, butane and sulfur. In initial stages of operation, production of sulfur is expected to run between 250 and 300 tons a day. Details of other output were not known.

D-X Sunray Oil Company has been approved by the parent Sunray Mid-Continent Oil Company for a refinery improvement and expansion program expected to cost between $8 and $10 million.

At its refinery in Tulsa, D-X Sunray will build a 12,000-barrel-a-day catalytic-reforming unit; a 12,000-barrel-a-day hydrogenation unit augmented by a 2500-barrel-a-day alkylation plant, and a 1500-barrel-a-day butane-isomerization unit.

Catalytic-reforming equipment at the company's refinery at Duncan, Okla., will be expanded from its present capacity of

For more data on advertised products, use Readers' Service Cards, last page.



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for GEARMOTORS

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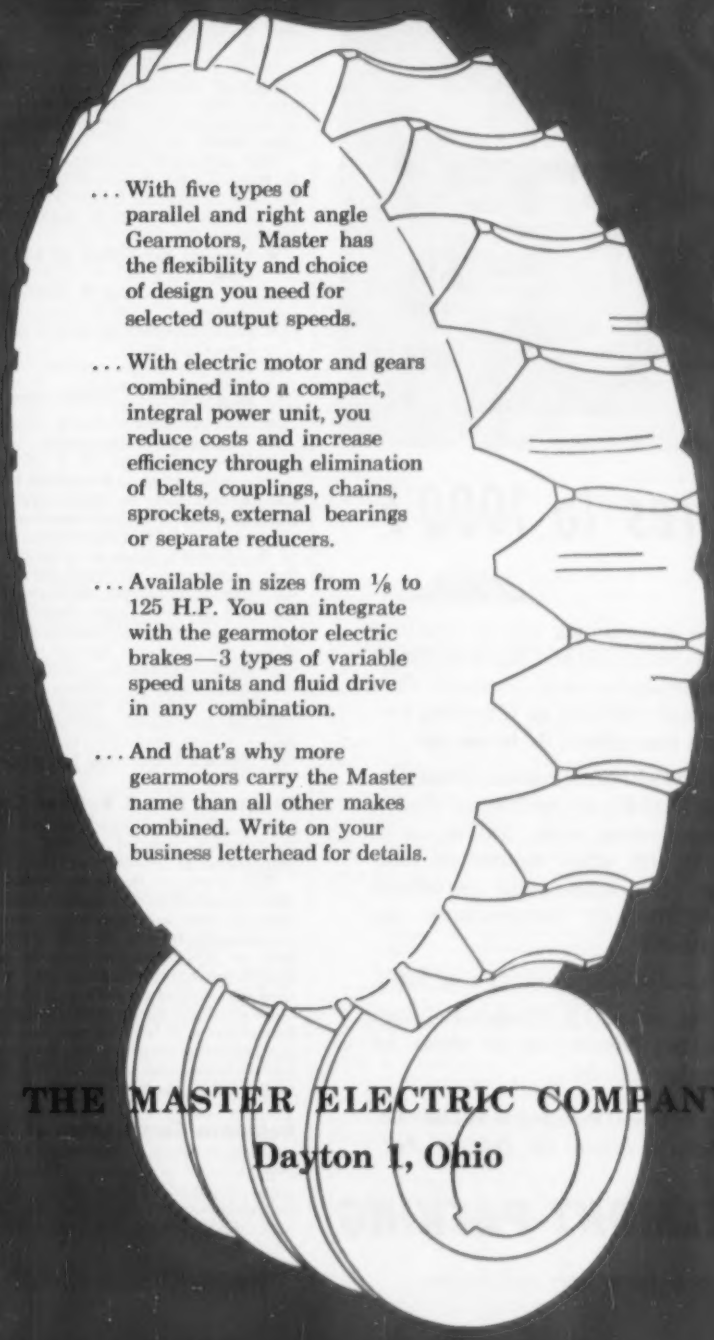


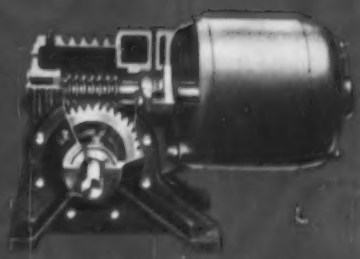
... With five types of parallel and right angle Gearmotors, Master has the flexibility and choice of design you need for selected output speeds.

... With electric motor and gears combined into a compact, integral power unit, you reduce costs and increase efficiency through elimination of belts, couplings, chains, sprockets, external bearings or separate reducers.

... Available in sizes from 1/8 to 125 H.P. You can integrate with the gearmotor electric brakes—3 types of variable speed units and fluid drive in any combination.

... And that's why more gearmotors carry the Master name than all other makes combined. Write on your business letterhead for details.

DOUBLE REDUCTION
Parallel Shaft Type



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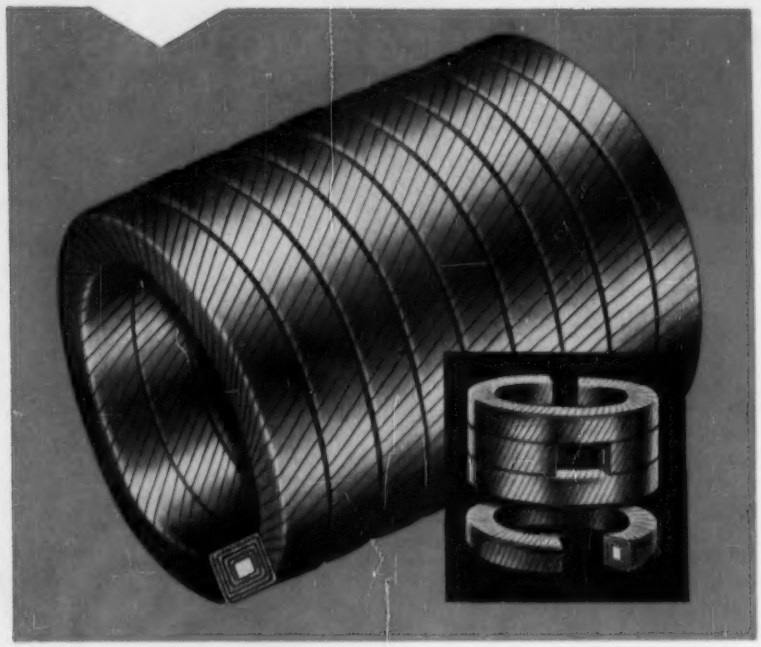
THE MASTER ELECTRIC COMPANY

Dayton 1, Ohio

BELMONT
Semi-Metallic* Packings



for temperatures to 1000°F

Here is a packing that is "custom made" to withstand high petroleum temperatures—and to remain flexible and efficient as a sealing medium throughout its longer life.

Use Belmont Twisted Aluminum Foil Packing on centrifugal shafts, reciprocating rods, valves, stillnecks and other equipment handling hot crude and petroleum distillates at temperatures up to 1000°F.

Available in spiral or ring form.

Ask your U.S. Gasket-Belmont Packing Distributor or write for Catalog No. 54.

* Twisted, spirally-wrapped Aluminum Foil Packing with or without dry braided asbestos core. Series 2080.

The Belmont Packing & Rubber Co.
Butler & Sepviva Sts., Phila. 37, Pa.

U.S. GASKET • BELMONT PACKING

Who's Building . . .

5000 barrels a day to 8000 barrels; an 8000-barrel-a-day pre-treater will be built to provide additional charge to the catalytic cracker, and a 10,800-barrel-a-day hydrogenation unit will be installed.

When the projects are completed in early fall, 1957, D-X Sunray's two refineries will have a total crude capacity of 113,000 barrels a day, with 53,000 barrels a day of catalytic cracking facilities; 22,800 barrels a day of hydrogenation processing, and 9000 barrels of alkylation capacity.

Petroleo Brasiliero, S.A., will undertake a major expansion of its 5000-barrel-a-day Mataripe refinery, increasing its capacity to about 37,000 barrels a day. When completed, the expansion will give Petrobras the largest refinery installation ever built in South America as a single project.

Work to be taken up includes the conversion of existing thermal-cracking facilities to other operations and the installation of equipment for the production of gasoline, diesel oil, LPG, lube oil and wax.

The refinery's processing plant will be engineered and designed by The M. W. Kellogg Company. When it is completed, the refinery will include facilities for these operations:

- Vacuum distillation of lube-oil fractions.
- Vacuum flashing of catalytic-cracker feed.
- Catalytic cracking with a new Orthoflow fluid unit.
- Catalytic polymerization.
- Propane deasphalting.
- Phenol treating.
- Wax finishing.
- Filter-aid manufacturing.
- Wax packaging.

The wax plant, to be one of the world's largest, will have a daily capacity of 60 tons, and the new 3000-barrel-a-day lube-oil plant will be Brazil's largest. Production of the lube-oil plant is expected to meet Brazil's domestic demand for five years, while products of the total expansion are expected to contribute materially to the country's 200,000-barrel-a-day refinery goal.

Kellogg installed a 2500-barrel-a-day thermal combination refinery at Mataripe in 1950, and built a duplicate refinery in 1952-53. Its present contract also calls for help see with Petrobras 'training program. (See **What's Happening in Industry.**)

Firestone Tire & Rubber Company will build a 75,000-ton-capacity plant for the manufacture of styrene at its new petrochemical center near Orange, Texas.

The plant, to be in operation in early 1958, is scheduled to produce the styrene required for the company's manufacture of synthetic rubber. It will be built adjacent to Firestone's recently-announced 40,000-ton butadiene plant which is scheduled for completion early in 1957.

By establishing its own facilities for the manufacture of both styrene and butadiene, the company becomes the first to produce the principal raw materials for the manufacture of its synthetic rubber.

Celanese Corporation of America has construction underway on a major expansion of its Bishop, Texas, chemical plant designed to increase by 25 percent its production of formaldehyde, methanol, acetaldehyde and other petrochemicals.

Reviewing New Books . . .

Process Control Analysis, by Millard H. Lajoy and E. Allen Baillif. One of the frontiers of instrumentation and automation is analysis of the closed-loop controlled process to effect maximum efficiency. This requires analysis of the frequency response of the system, including the mathematical treatment of the process and its controller elements.

This book is based on a simple representation of the closed-loop system in terms of elementary resistance and capacitance elements, which give rise to ordinary, linear differential equations of fairly low order. These defining equations are then solved analytically, giving insight into the analog-computer and stability techniques which conclude the book.

This approach is based on the fact that most processes can be simulated by simple R-C elements, and on the fact that this approach is a simple preliminary step for advancing into the more complicated analysis techniques, including transfer-function representation of the system. Because the jump into the latter, without full knowledge of the former, might cause a loss of feel for the system, this book represents an essential first step for the control engineer or instrument man who wants to extend his vision into the field of frequency response of the closed-loop controlled system.

(Instruments Publishing Company, Inc., 845 Ridge Avenue, Pittsburgh 12, 63 pages.)

Interchangeability of High-Btu Oil Gases and Natural Gases, by E. F. Searight, H. R. Linden, D. L. Nicol and E. S. Pettyjohn. An answer to problems faced by distribution companies which must supplement their natural gas supplies to meet peak loads is provided in this research bulletin.

This study demonstrates the effect of operating conditions and modification with diluents on the substitutability of oil gases, and reports the maximum percent oil gas in mixtures of oil gas and base natural gas which exhibited satisfactory combustion performance on critical burners and critical and contemporary appliances.

The experimental determinations on which this work is based were carried out in the utilization laboratories of the Institute of Gas Technology, under sponsorship of the American Gas Association.

(Institute of Gas Technology, Illinois Institute of Technology, Technology Center, Chicago 16, 59 pages, $5.)

Accidental Scientific Discoveries, edited by Bernard E. Schaar. This booklet describes 20 important scientific discoveries, summarizing the work of such men as Priestley in the discovery of Oxygen, Belling as he developed the Smear Technique, Rontgen with X-Rays and Courtois with Iodine.

The booklet also includes intriguing stories about the discovery of Rayon, Insulin, Petroleum Jelly, Photo-Sensitive Plates, Crystallography, Aniline Dyes, Plastics, Thiophene, Dental Amalgrams, Benzene Ring and other historic advances in science.

(Schaar and Company, 754 West Lexington Street, Chicago 7, 64 pages, free if requested on company letterhead.)

Plant Operators' Manual, by Stephen Elonka. This book shows steam engineers, plant mechanics, and other power services personnel how to maintain and operate equipment, giving methods and pointers which will help them not only in their daily work but also in future upgrading and license examinations. A major feature of the book is its sequence illustrations, with each operation shown step-by-step in photagraphs or line drawings.

Boilers, steam engines, turbines, diesel engines, pumps, compressors, and similar equipment are covered. A wide range of practical materials is provided, covering such jobs as setting valves of a steam engine, charging a Freon compressor, overhauling a bearing, and timing and setting diesel engine valves.

This manual also tells how to use the most recent maintenance tools—the reflectoscope for detecting cracks in metal—the deflection gage for finding misalignment in large diesel crank bearings.

(McGraw-Hill Book Company, 327 West 41st Street, New York 36, 292 pages. Illustrated, $5. For sale by Gulf Publishing Company, P. O. Box 2608, Houston 1, Texas.)

National Motor-Gasoline Survey, Summer 1955, by O. C. Blade. This circular reports the properties of over 4800 samples of motor fuel as sold through service stations in the U. S. It is the results of a cooperative effort between the American Petroleum Institute and the Bureau of Mines.

The samples represented were collected during June, July, and August, 1955. The information on these samples were obtained by laboratories of various refiners, motor manufacturers and chemical companies, and submitted to the bureau for compilation.

(Bureau of Mines, Department of Interior, Washington, 24 pages.)

Bibliography of Solid Absorbents, 1943 to 1953, by Victor R. Deitz. This anotated bibliographical survey of the scientific literature covers the period from 1942 to 1953 and contains approximately twice as many references as are found in the bibliography for 1900 to 1942.

A complete author index and a very complete subject index are features of this circular. The utility of the subject indexing is contained in the main heading which is based on the type of adsorbent and the subheadings which cover some general aspects of the gas or solution phase.

The effects of adsorbents on particular gases, liquids or solutions are of particular importance to the petroleum, sugar, biochemical, agricultural, mining, and metallurgical industries as well as in water purification. Since catalytic processes involve adsorption as an essential step, this bibliography is of especial value to those interested in catalysis.

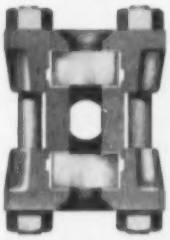
The preparation of this volume was conducted as part of a program of research under the cooperative sponsorship of the Bureau of Standards and the Bone Char Research Project, Inc.

(Government Printing Office, Washington 25, D. C., 1528 pages, $8.75. Order National Bureau of Standards Circular 566.)

Strahman

HIGH PRESSURE GAUGES

USED IN **REFINERIES** *AND* **CHEMICAL PLANTS** *THROUGHOUT THE WORLD*



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STRAHMAN VALVES, Inc.
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For more data on advertised products, use Readers' Service Cards, last page.

Are Your Employe Communications Effective?

There are two good ways to go bankrupt—(1) miscalculate the economic side of your business and (2) under-rate or over-simplify employe relations.

Dr. Alan A. McLean
Hartsdale, New York

TODAY MORE than ever before, there are two good ways of going out of business. One is to miscalculate the economic side of one's business—one's buying, selling and merchandizing; the other to under rate or over simplify one's employe relations. Employe relations simply cannot be brushed off by people who are too busy with tangible problems of manufacturing and distribution to bother with them.

The real problem is to make a man feel as important as he really is; by making him as important as he is capable of being. Superficially it may appear that the goal of increased productivity on the one hand and the goal of meeting needs on the other are in conflict. We recognize that the company can supply the best of equipment, materials and methods, and the the worker can bring on his job the best training, experience and health, but unless his attitude is a healthy one, he won't turn out much work.

The healthy attitude as developed by employe communications is of major importance. It is the meeting of these human needs, the stimulation of these healthy attitudes through communication that become the problem.

In an effort to tackle such a problem we must first know a great deal more about the individual worker and the way he reacts to various types of communication, to various patterns of behavior, stress, emotions, worries, and what he really wants out of his job.

One of management's major objectives is promoting a climate favorable to the growth of understanding. How can he do so through employe communications?

Feedback—The audio-engineer who studies communication by means of electrical circuits and oscillographs is inclined to think in terms of a communicated signal. The prime signal and its clarity are important to him, but he recognizes certain patterns of interference which add distortion to the original signal which he attempts to minimize. He also has some control over clarity of the original signal and the amount of distortion. He monitors what he hears and in doing so has to maintain a continuous check upon the fidelity of the sound. In so doing, he is able to keep a close check on extraneous noise. It is the process of continuous feedback of information about the final signal that keeps him posted on its quality.

With a sound, he is quite aware of the fact that the more distortion, the less information coming across and of course, the less the noise, the greater the clarity of the information. In short, the undesirable interference with the communication monitored by the audio-engineer is measureable through a process of checking the signal at various points to determine the amount of distortion.

The industrial communicator has no such built-in feedback reports to accurately indicate the effect of his communicated information and the clarity of his signal. To be sure, he has some indications of the receptivity and the reaction of his audience. These are not entirely accurate and offer many limitations. The signal cannot be changed or monitored as it eminates from his pen.

The first major point then, is that *we cannot think of clear cut, precise message reception.* We must also consider that *interference and distortion itself conveys valuable information.* The editorial comment accompanying factual information is sometimes far more important and more meaningful to a group of employes than bare facts.

Management is concerned with the transmittal and exchange of information in the industrial setting. Management recognizes the increasingly important role of such communication in the effective conduct of business. The oil industry in particular, a leader in advances such as automation, feels

Meet the Author

ALAN A. McLEAN is a psychiatrist, serving American Cyanamid Company and New York Telephone Company as a psychiatric consultant, Cornell University as a faculty member in its College of Medicine, and The New York Hospital as part of its attending staff. Educated at the University of Washington in Seattle, New York University and Long Island College of Medicine, Dr. McLean received his psychiatric training at Western State Hospital in Tacoma, Wash., at Oregon State Hospital in Salem, and at Cornell in the College of Medicine and the School of Industrial and Labor Relations. While at Cornell, he held a two-year fellowship in industrial psychiatry sponsored by Carnegie Foundation. Part of this fellowship was used in a project regarding the selection of overseas employes for Standard Vacuum Oil Company. Dr. McLean's professional experience also includes service with both the Navy and the U. S. Public Health Service.

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that it must keep ahead of most industry in the quality, accuracy and mobility of its communications processes.

A reduction in the amount of interference, noise, static and distortion in communicated messages is important. So too is understanding of the noise and distortion when it is present. And understanding reasons behind the seeming distortion and static is equally important.

The psychiatrist generally is struck by the fact that no single message has the same meaning for each person involved. Each brings into the communication system individual motives, values, feeling and in short, his individual background and way of looking at things.

With the need to communicate clearly and be understood on the one hand and with the tremendous difference in receptivity on the other, problems are posed for industrial communication. In must be understood that some barriers to communication can never be entirely surmounted.

How does one communicate? The smile on the face of the supervisor as he circulates a memorandum from top management is perhaps more important than the memo itself. By leaving unsaid as well as by saying, by ignoring rumors or by answering them, by verbal inflection and attitude, communication is born.

Let's take a look at several currently popular methods of communication on the industrial scene.

Initially Negative News—At times, in an effort to clarify misleading information and rumors, management may issue a denial. On the face of it this seems quite logical. The same automatic, almost reflex impulse to communicate in order to deny is found more often in day to day relationships in any plant. Sudden contradictions and exceptions to long established procedures and policies are occasionally necessary. But when presented without explanation and in a seemingly critical and contradictory fashion, they only serve to arouse feelings of hostility.

For instance, if a news story in a company publication were to report that it was *not* true a certain number of plants were to be sold to a competitor, feelings of insecurity and anxiety would develop in many individual employes. And if a first line supervisor were to abruptly challenge, without explanation, the way a technician was handling a routine assignment, he would meet with considerable resistance.

Presenting information of any sort in a negative way is always likely to arouse suspicion, doubt, resentment and hostility. On the other hand, with explanation of the reason why a company feels it necessary to present negative news, there is a fair chance of allaying these same feelings.

Overcommunication—In an effort to communicate effectively, some managements overdo the process and swamp the circuits with too many messages. These may include needless exhortations, petty comments and irrelevant details. It may include bringing too many people into a problem. It may mean a barrage of so many formal and informal communiques, magazines and newspapers and policy statements that it becomes impossible for any employe to keep up.

In any of these situations important information is apt to be lost in the shuffle. It is certainly possible to overdo a good thing. Another aspect of overcommunication is what might be called communication *before the fact*. This refers to communications of half-formed policies and also to rumors that are intentionally spread to sound out various groups of employes—the well known trial balloon technique.

Many necessary industrial moves, such as the relocation of machinery or the introduction of new procedures, involves change for individual employes. Any communications on these subjects is liable to be anxiety producing. Premature news concerning these subjects can be disturbing. *The time to communicate is when you can answer more questions than you raise.*

Distorted Communication—The underlying attitude and feelings, the individual values and ideas of individual employes—all these must be taken into account in planning a communication or in working on a communications problem.

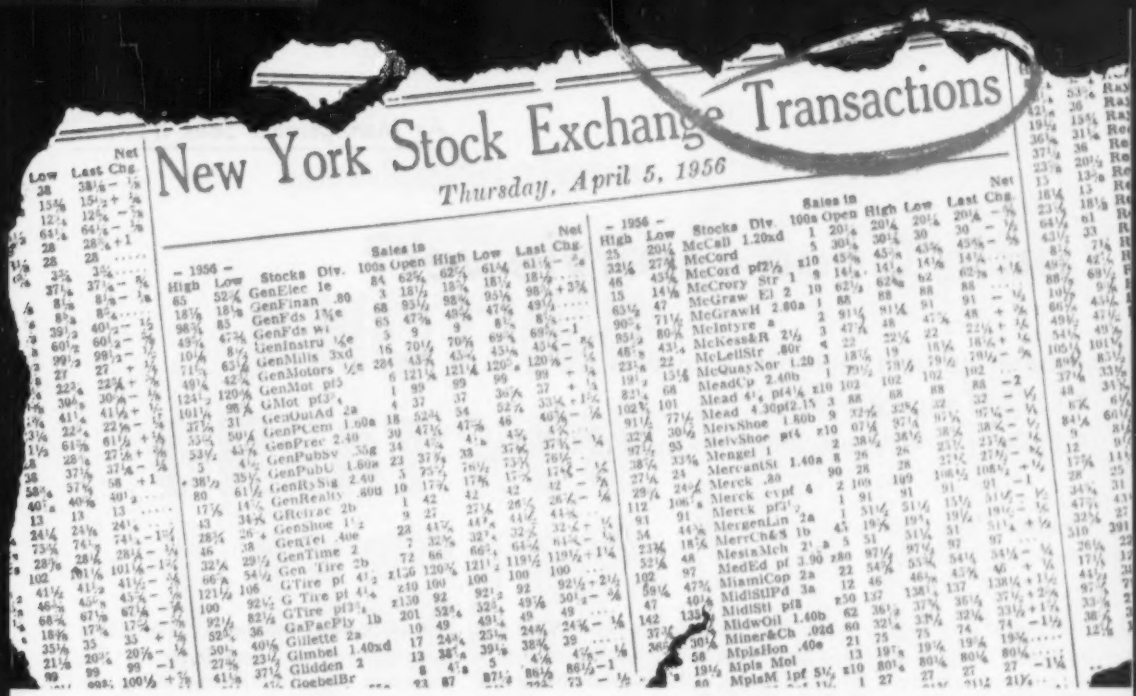
We might say that the effectiveness of any given communication is determined by its clarity and even more, by what the receiver understands of the spirit behind it. Yet it is not always easy or possible for the receiver to identify the underlying attitude of the sender. When management takes for granted its message will be perceived by the employe as being sincere and straightforward, this is quite often not the case. One common pitfall is to assume that there is a basic agreement underlying the relationship between management and the individual worker when this is simply not so.

In its monthly news letter to the employes, a company management may insist that, at the present time, industry is extremely competitive—that it is therefore urgent for each worker to increase his output so that the company may continue to get its share of available orders. This would seem to be perfectly reasonable. Yet it may be interpreted by employes as an attempt to simply speed up production with an inevitable lay off around the corner once current orders are filled.

Communications Lack—Many companies suffer from a dirth of information flowing either up or down communications channels. No business can be conducted in a vacuum. This is particularly so in the dynamic oil industry. A lack of communication seems most particularly destructive in the face of impending change. Major management decisions frequently must be made in a relative vacuum. On the other hand this does not mean the majority of changes must be put into effect precipitously and without accurate warning. With no communication in a situation where it is widely known that a change is about to take place, many rumors spring into being with the result of much confusion and uncertainty.

A partial communications lack is embodied in the policy, "We tell them only what they want to hear." How smart a maneuver is this? This occasionally applies to communications directed from management to the hourly group. But passing only pleasant facts upward through various levels of management is more often the case and contributes to gross inefficiency. Sure, we all like to hear about the good things of life. No one likes to arouse antagonism in his supervisor. The creation of a climate in which such communications can be presented without fear of unjust reprisal is one of management's important tasks for effective two-way communication.

The cornerstone of sound employe relations is the practical application of well understood concepts and policies of good communication. ##



New York Stock Exchange Transactions

Thursday, April 5, 1956

– 1956 – High	Low	Stocks	Div.	Sales in 100s	Open	High	Low	Last	Net Chg.
65	52⅞	GenElec	1e	84	62⅝	62⅝	61¼	61½	– ⅝
18⅛	18⅛	GenFinan	.80	3	18⅛	18⅛	18⅛	18⅛	.....
98¾	83	GenFds	1⅓e	68	93½	98¾	93½	98⅛	+ 3⅜
49¾	47¾	GenFds wi		65	47⅞	48¾	47⅝	49⅛	.....
104	8½	GenInstru	⅛e	5	9	9	8½	8½	– ⅛
71⅝	63½	GenMills	3xd	16	70½	70⅞	69⅝	69⅝	– 1
49¼	42⅝	GenMotors	½e	284	43⅞	45¼	43¼	45⅛	– ⅝
124½	120⅜	GenMot	pf5	6	121¼	121¼	120⅝	120⅝	– ⅛
101¾	98⅜	GMot	pf3½	1	99	99	99	99	+ ⅛
37⅞	31	GenOutAd	.2a	4	37	37	36⅞	37	+ ⅛
55½	50⅛	GenPCem	1.60a	18	52¾	54	52⅞	53¾	+ 1⅝
53¾	44⅞	GenPrec	2.40	39	47½	47⅝	46	46⅜	– ⅛
3	3	GenPubSv	.35g	34	4¼	4⅛	4⅛	4⅛	.....
38½	35½	GenPubU	1.60a	23	37⅝	38	37⅛	37⅜	– ⅛
80	61½	GenRyScg	2.40	5	75½	76½	73⅞	76½	.....
17⅝	14⅞	GenRealty	.80b	10	17¾	17⅝	17⅜	17⅝	– ⅛
43	34⅜	GRefrac	2b	1	42	42	42	42	– ⅛
28¼	26	GenShoe	1½	9	27	27⅛	26½	26⅝	– ⅛
46	38	GenTel	.40e	23	41¾	44⅞	41⅞	44⅜	.....
32⅛	29½	GenTime	2	7	32⅝	32⅞	32⅛	32⅜	+ ⅛
66⅞	54½	Gen Tire	2b	72	66	66¼	64¼	64¼	– 1⅛
121½	108	GTire	pf 4½	z150	120⅝	121¼	119⅛	119⅛	+ 1⅛
100	92½	G Tire	pf 4¼	z130	100	100	100	100	.....
92½	82⅛	GTire	pf3⅓	201	92	92½	92	92½	+ 2½
52⅝	36	GaPacPly	1b	10	52⅝	52⅝	49⅛	49	– ⅛
50⅛	40½	Gillette	2a	17	49	49¼	32⅝	49	.....
27⅝	23½	Gimbel	1.40xd	13	24¼	25⅛	24⅝	24⅝	– ⅛
41⅛	37½	Glidden	2	8	38⅛	39½	38⅝	39	.....
		GoebelBr		23	4⅛	5	4⅛	4⅛	– ⅛
					87	87½	86½	86½	– 1

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GENERAL REFRACTORIES

Are You a Good Interviewer?

The most common faults in interviewing are . . .

- **Lack of a specific plan**
- **Failure to let interviewee do most of talking**

Dr. Harold A. Edgerton, Vice President
Richardson, Bellows, Henry & Company
New York City

INTERVIEWS ARE our most used personnel tool, and as such are used, misused, abused and confused. Every interviewer feels that he is at least fairly competent in handling prospective employes, but when two or more interviewers independently interview the same person, do they come up with the same conclusions? There is not even adequate agreement among interviewers who participate in or listen to the same interview.

With all its known shortcomings, we will continue to interview. The answer has to be in terms of improvement of interview technique and skill. This article presents some common sense suggestions on how you can make some improvements in your skill as an interviewer.

Establish Your Objectives—The first step in improving skills is to define just what you want the interview to tell you. Such definitions are best expressed in terms of questions. For example: "Has this man had experience which should make him a good field geologist?"

You need to know, of course, what kinds of experience are pertinent to the question, and just which experiences indicate a good field geologist and which would suggest mediocrity. "Is there anything in his background which would indicate that he might have trouble in getting along as a member of a field party?" Friction with associates, attitudes of looking down his nose or belittling associates, being the "big I am," being strongly opinionated, and the like, may be indicated for this question.

Does he have characteristics which might make him an undesirable employe? What are his motivations? Why does he want the job? What are his ambitions? Why did he leave former jobs, etc. All these may bring out some useful evidence on motivation.

The second step is to list—write them down on paper—a number of topics for discussion to bring forth information which will shed some light on the questions you want to answer. These will, of course, be related to your purpose. Some of these questions might be: How did you like the people in that organization? Who was your boss on the last job? How well did he know his stuff? What kind of a situation do you expect/hope to have ten years from now? Just what did you do on that job? Any headaches in supervising a group like that?, and so forth.

Next you will need to know something of the man you are going to interview. Why is he coming to the interview? How is he likely to react to the interview? Does he have a particular point of view which you should consider?

Interviews should be held on schedule, with a minimum of inconvenience. The place of the interview should provide sufficient privacy for the purpose and topics of the interview. The more personal the interview the more privacy needed. Privacy may be either auditory or visual, usually both. Privacy also includes freedom from interruptions, and from distracting noises and events.

Above all, be ready to listen. Listen to what the interviewee has to say in response to your questions. Listen to how he says what he has to say as well as to what he says.

Most situations permit you to take notes. Do that inconspicuously but not secretively.

Conducting the Interview—Gain and deserve the confidence of the man you are interviewing. Keep his confidence throughout the interview. Your interviewee can "give" more and better when he is at ease and when he knows the purpose of the interview.

First of all put your man at ease. Greet him like you are glad to see him. See that he is physically comfortable, a good chair, not facing the light, etc. Start the conversation yourself, talking briefly about things unrelated to the interview but of interest to your man. Give both of you a chance to relax and feel at ease with each other. Then you are ready to go ahead with your interview.

Begin with an explanation of the purpose of the interview. Indicate how he relates to the purpose, why he should be interviewed, and in general, what you expect to learn from the interview. Start with questions which are general, questions which give the interviewee an opportunity to talk. Questions should be the kind which call for longer answers and cannot be answered by a few words or a yes or no. Such specific questions may come later. Frequently they will be answered before they are asked, if the man is given a chance to tell about himself in his own way.

As interviewer, you have two jobs: to be a good listener, and to provide the questions and comments which enable the interviewee to create the answers which you are seeking.

Once the interview is really "warmed up" probing questions may be used to clarify information, attitudes and feelings. Such questions should be asked as a means of getting

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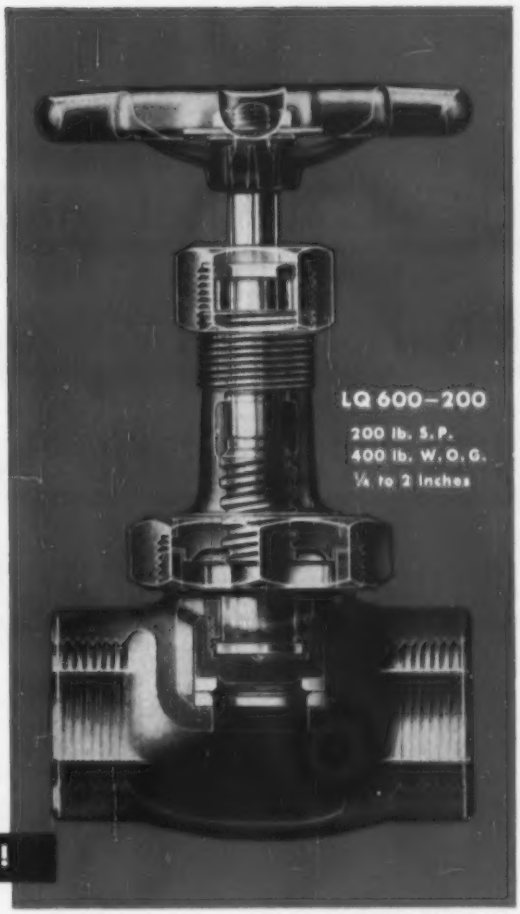

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better understanding, more detail, a clearer picture of attitudes and feelings, never as cross examination.

Your purpose is not that of provoking an argument, but that of understanding clearly the man who is being interviewed. Sincerity, patience and understanding are useful for this purpose.

Avoid putting your man on the spot or making him look stupid or foolish. This does not mean that you should not ask pointed questions, but rather that they avoid that personal "bite."

A straightforward and frank approach is more fruitful than one which looks shrewd or clever. The latter makes your man feel that he should be careful not to step into a trap.

Your questions should be aimed at the purpose of the interview but not be loaded or leading questions. If your questions imply answers, you have biased the interview and obtained, in part, support for your preconceived judgment of the individual or his situation.

Be sure you are understood. It is not at all satisfying to have an interviewee answering questions you did not think you asked and failing to answer those you believed you asked. Use language which will be understood by your interviewee. It is not necessary to use his language, but use common clear words. Use simple rather than involved sentences, and in so doing ask only one question at a time. Interpret the answers you hear at once so as to be sure that you have obtained the information you seek and have it straight.

When and how to record interview data will be determined by the kind of record you need to keep. If you want exact quotes of words, phrases or sentences, or if you need to keep a considerable record of details, then make notes as you interview. If general impressions, without much detail, are required, records of the interview may be made immediately after the close of the interview. It is not necessary to apologize for making notes. The fact of the interview itself should imply that some sort of record should be retained.

Closing the Interview. Make the interviewee feel that he has given you

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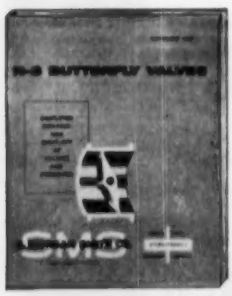

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information that you are seeking, and that he has cooperated freely in so doing. He should also feel that he has benefited from having talked with you. Such closing comments as the following may help to terminate the interview on a pleasant note. "You have given me a good picture of your background," or "You have helped to clear up a number of points in my thinking."

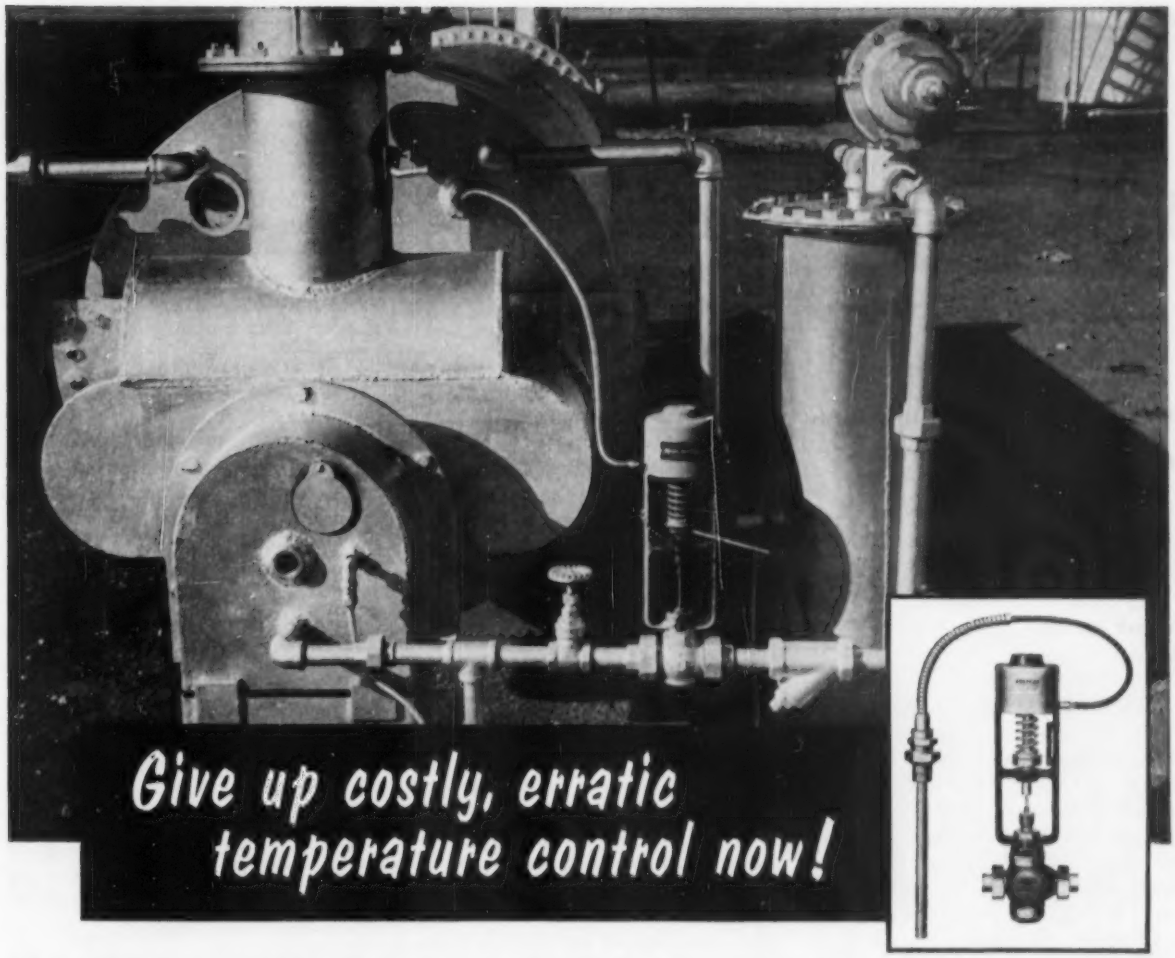
Commitments should be made regarding time of further action, who will take such action, etc., if the purposes which the interview serves call for such further steps. Allow no implications of further action which are not really honest. Dont's let it be implied that he is the top candidate if he is not. Frankness is called for, but not brutal frankness.

How to Improve Your Interviewing—The brief suggestions given should help improve your interviewing techniques. The two most common faults in interviewing are lack of a specific plan for conducting the interview, and in failing to let the interviewee do most of the talking.

Self-criticism of ones own performance, and if you can take it, criticism by others are effective tools. A recording of your interview played back to you later furnishes the opportunity for you to hear yourself as others hear you. It may be noted that this method of using recordings of one's own interview is one of the best devices for improving your skill in interviewing. As you listen to your recording you should ask yourself some questions about the performance.

Your questions should include the following:

1. What evidences were there of a specific plan in the interview?
2. In what ways did the interview wander off the subject and purposes?
3. Did the interviewee answer the questions you asked?
4. About what percent of the interview time was occupied by your own talking?
5. What questions did you fail to ask?
6. What different conclusions regarding the interviewee or interview results do you reach after hearing the interview as an observer rather than a participant? ##



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"THIS HAS been one of those days," the refinery executive told his wife at the supper table, "Just a month ago we spent a lot of money and time working up a good safety program . . . held meetings . . . gave instruction . . . did everything we could to put it over . . . and do you know what? The men have as good as forgotten the whole thing today!"

The program was excellent, carefully thought out and programmed, except for one thing . . . no effort was made to adapt it to the specific thinking of the employes or make each man an important part of the program.

Many a good safety program has floundered on neglect of this one point. It should be an even more important part of planning than drawing up the general program itself—for no safety program in any refinery can ever be any better than the employes of that refinery make the program.

We've checked into several score such safety programs where employes wholeheartedly took part in the program and put it over. The five steps to follow are the important ingredients of those successful programs. Each and everyone can be adapted to any refinery operation, large or small, regardless of the size of staff.

1. Avoid Generalities

The single most important factor we have to keep in mind is that safety education has its limits when applied to employes. Generalities do not produce results. In nearly every case they leave the employes indifferent and disinterested. The program itself must be loaded with specific HOW the individual employe can put safety to his own use on his own job.

Mass safety education is satisfactory only when devoted to an effort to impress employes with the need for greater attention to safety and what it will mean to each of them individually. It has been proved practical only in selling generalities; never in specific application by each man to his own work.

Experienced safety education executives point out that the education plan must not only teach the merits of safety but employes must be told what specific dangers in their own line of work should be guarded against and what specific things they can do themselves to avoid injury.

It should also be kept in mind that the process requires discipline in mind and body and that this must be one of the primary points of education. Until it has been impressed on employes they will never give the proper attention to even the specific applications of safety in their own jobs. Many experts point out that well trained men avoid injury on dangerous work.

2. Get Your Foremen Interested

The educational program is always more successful when an initial effort is made to arouse the interest of foremen and department heads prior to presentation of the program to the individual employes. The foreman is always in the best position to do the actual educational job. However, it must be kept in mind that the average refinery superintendent or foreman is usually so busy on other problems that a specific effort must be made to convince him that his own special attention to safety is required in the program.

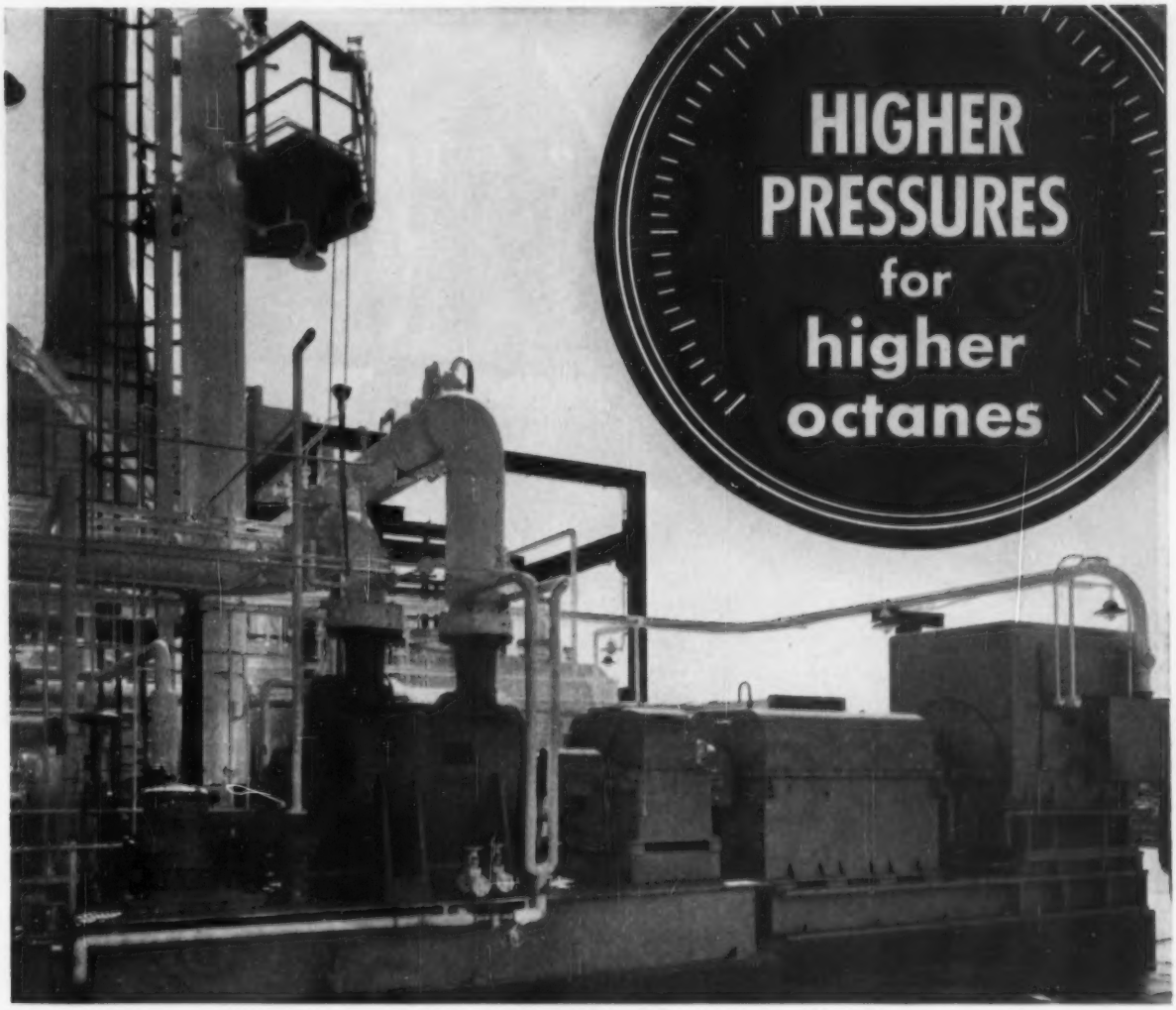
Experience has shown that this can be accomplished much more successfully when the foremen, superintendents and department heads are actively consulted in formation of the safety education program as to material it should include and how it should be carried out.

The most successful safety education programs have always tied such immediate supervisors closely to the work. Four principle parts of supervisory participation are usually included. These are:

- Asking for their assistance in determining the standards for guarding equipment.
- Requesting their specific suggestions in formulating the safety rules as they shall be set up for each such supervisor's department.
- Fixing their responsibility to investigate all accidents and decide what must be done to prevent the recurrence of each such accident.
- Making it their responsibility to review all safety suggestions and records and decide upon their particability not only in their own departments but for the refinery as a whole.

Once this has been done there are many steps the refinery management can take to bring the safety program closer to employes and generate their cooperation. In one company, for example, where a program of mass meetings had been ineffective and the safety education venture had come to a virtual standstill, it was found that emphasis placed on specific safe practice rules re-kindled that interest and brought results.

Education of individual workers in this plant progressed to a satisfactory level after this was done because the new safe practice rules applied directly to the work of these men. Then a supervisor's report of accident in-



There's no refinery compression job today that can't benefit from the proved economy and dependable performance of modern I-R compressors — available in types and sizes to meet every process requirement. Your I-R representative will be glad to help you work out the best solution to your particular problems.

I-R compressor design keeps pace with latest advances in refining technology at Union Oil Company

In the new catalytic reforming processes for production of high octane gasoline, large volumes of low-density hydrocarbon gas must be compressed to pressure levels of up to 700 psig. These difficult requirements are easily met with Ingersoll-Rand multi-stage centrifugal compressors of the "barrel" or double-case design, as shown above.

For instance, in catalytic reforming service at the Union Oil Company's Oleum refinery, the above I-R centrifugal unit compresses 2670 cfm of 85% hydrogen gas from 473 psia to 669 psia. This 6-stage, double-case compressor, with pressurized oil shaft seals, is driven by a 3500 hp, 1750 rpm motor through a 4.55-to-1 speed increasing gear. Outer barrel is of forged steel and the removable inner casing is horizontally split to permit inspection or removal of the rotor.

12-291

Ingersoll-Rand

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COMPRESSORS • AIR TOOLS • ROCK DRILLS • TURBO-BLOWERS • CONDENSERS • CENTRIFUGAL PUMPS • DIESEL AND GAS ENGINES

For more data on advertised products, use Readers' Service Cards, last page.

New tower goes to English plant. Light, efficient, all-Monel nickel-copper alloy "Turbogrid" design reduces both construction and operating costs of this mesityl oxide unit designed by Shell Development Company.

New, all-Monel mesityl oxide tower points way to lower fractionating costs

Shell—*designed Turbogrid unit is expected to operate at high capacity with low maintenance.*

Things are popping in bubble tower design.

Take this all-Monel* nickel-copper alloy distillation tower. When all facts are in, it may prove the forerunner of all-Monel alloy construction for units where only carbon steel is used today. With this type of alloy construction, longer tower and tray life, lower maintenance, and greater operational versatility can be expected.

The column (shown here on its way to the Stanlow Refinery of Shell Refining and Marketing Company in Cheshire, England) separates mesityl oxide from hot, acid-treated diacetone alcohol. It is 55 feet high, fitted with 40 Shell Turbogrid trays . . . stamped from Monel alloy plate.

Slotted grids provide highly efficient vapor-liquid interchange. There are no dead zones. Pressure drop per tray is low and very high throughput is obtained. Fouling is slow. Cleaning easy.

The Monel alloy trays are amazingly light: because of simple construction (which results in low liquid hold-up) . . . and because the strength and corrosion resistance of the alloy permit thin gauges.

The result? Much lighter, less costly structure, and lower fabrication and construction costs.

In this instance the anticipated cost differentials justified Monel nickel-copper alloy for tower shell as well as trays. It is expected that actual operation will reveal additional savings. This would extend the use of this alloy to many refining and petrochemical fractionators where corrosion has been an accepted trouble in the past.

If you face this situation and would like to discuss the possibilities with one of Inco's Development and Research engineers, contact . . .

*Registered Trademark

THE INTERNATIONAL NICKEL COMPANY, INC.
67 Wall Street New York 5, N. Y.

INCO Nickel Alloys

Monel . . . *for minimum maintenance*

vestigation was developed and put into use. The supervisor was required to locate the essential facts and make use of them. This step made supervisor cooperation in safety education automatic.

3. Hold Department Conferences

In another plant the conference type of safety education was decided upon as reaching employes closest. In addition to the regular program periodic meetings of foremen and key workers in each department were held. The subjects were selected in advance of each meeting and plans were made for which employes would take an active part in the leadership of such discussions prior to every meeting.

Three general topics were selected:

- The principles of accident prevention.
- Major causes of departmental accidents.
- What corrective action was to be taken.

Here again a lagging safety education program suddenly sprang to life and secured full employe cooperation. This end was obtained because the individual's part in the program was strongly encouraged. Set speeches were avoided at every such meeting with each being conducted as a round-table forum. The net result was a thoroughly workable safety program as well as one in which each employe had a particularly keen intrest because he had an important part in creating the whole safety program.

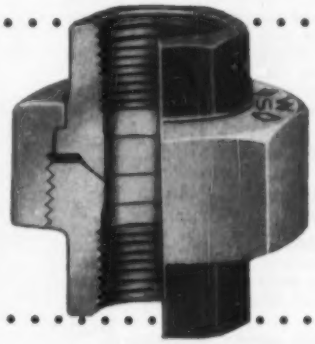
4. Encourage Employe Participation

In a third organization where a generalized safety education program was obviously getting nowhere, results were obtained by putting all emphasis on safe practice rules themselves. After a series of discussions with specific groups of employes a new set of such rules was formulated from the suggestions and ideas the employes had offered in these meetings. These were then mimeographed and released in pamphlet form for the employes to take home and study.

Another program was made particularly successful when the safety director added an unusual feature in the form of a safety playlet he had

W-S FORGED STEEL UNIONS...

These Features are YOUR GUARANTEE of a Safe, Tight Union Connection:



1. FORGED STEEL CONSTRUCTION— ASTM A-105, GRADE 2
2. SPHERICAL-TO-ANGLE MATING SURFACES
3. ANTI-GALLING, CADMIUM-PLATED NUTS

W-S Forged Steel Unions give you the kind of protection you need in high pressure piping systems. They're designed with precision-machined spherical-to-angle mating surfaces for positive seating, free from leaks even when pipes are slightly out of line. Cadmium-plated nuts resist galling and seizing and forged steel construction gives you the extra strength you need in high pressure service.

W-S Unions are available in 3000 lb. class, sizes ⅛" to 3" in screw-end and socket-welding types. Send today for your copy of Bulletin U-1.

Sold Through Leading Distributors.

W-S FITTINGS DIVISION

H. K. PORTER COMPANY, INC.
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Suggested as a speculation

The Unique Profit Story Behind

OIL WARRANTS

How You Can Prepare for This Year's Similar Opportunities

There are large speculative gains to be made in Oil Stock warrants – often 4 to 5 times those available in ordinary stocks—by investors able to devote a part of their funds for this purpose, and frankly recognizing both the risks and the exceptional profit possibilities involved.

As a typical example, a $1,000 investment in Canadian Oil Cos. Common Stock in September 1953 would have grown to $2,000 by August 1955 – 22 months. *In the same period, however, $1,000 put into the Company's Warrants increased to $11,000, or more than five times the initial cost.*

This is only one out of a long authentic record of similar cases where $1,000 purchases have become worth $8,000, $10,000 and even $19,000 in a relatively short time.

2 STRIKINGLY SIMILAR CHANCES FOR PROFITS IN WARRANTS

We've been searching the oil field over for other potential big-gain warrants like Canadian Oil Cos., and have just uncovered two exceptionally promising new Canadian warrants. One, a little company with big-name backing, gives you 2 special advantages—first, for capital safety a large royalty play with a tremendous built-in growth capacity; second, for powerful capital gains a wildcatting program with truly electrifying discovery possibilities. The other is a smartly-run young LP-Gas Company which is now making "seven-league" growth strides.

The stocks of these two stand-out companies are capable of sharp upward gains. And, if and when the stocks do, the two warrants (both priced under $3.20) could prove to be a profitable investment.

The great gain potentials that we see in these two issues have as yet remained largely undiscovered by investors. As a result, these warrants now give you, we believe, two outstanding ground-floor profit opportunities. Find out about these big profit-potential warrants today. Send immediately for this new Report on: –

"2 CANADIAN OIL WARRANTS WITH BIG PROFIT POTENTIALS"

You also receive 2 additional new Reports entitled:

"THE 'ONE BEST BUY' IN CANADIAN OIL STOCKS" and

"27 CANADIAN OIL STOCKS FAVORED BY THE PROFESSIONALS"

This big 3-way Package Report is yours along with a full 5 weeks' trial subscription to the OIL STATISTICS BULLETIN plus the CANADIAN OIL REPORTS for only $5. Return coupon today!

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Yes – send me at once (1) your new Report "2 CANADIAN OIL WARRANTS WITH BIG PROFIT POTENTIALS", (2) your 2 additional new Reports "THE 'ONE-BEST BUY' IN CANADIAN OIL STOCKS" and "27 CANADIAN OIL STOCKS FAVORED BY THE PROFESSIONALS", (3) Your OIL STATISTICS BULLETIN plus the CANADIAN OIL REPORTS for a period of 5 weeks. (This offer open to new readers only.)
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180

written in cooperation with the publicity department. The theme described a "dumb" workman who did everything wrong and held interest by the laughs he produced. A check after its presentation showed, however, that the average employe remembered a great deal more of the specific safety ideas than he had following a series of cut-and-dried lectures which offered the very same suggestions.

This particular playlet was even more successful because the men themselves played the roles. Following presentation of the playlet another successful step was taken—selected key men were chosen to set the example. Each of these men was chosen because he was looked up to and respected by the other workers on the job with him. It was found that what he said and did on the job impressed the other workmen more forcefully because they usually looked up to and respected his good judgment.

5. Use Safety Suggestion Boxes

Safety suggestion boxes have also been used in many organizations to heighten employe interest in and participation of the safety education program. Monthly cash prizes for best suggestions have proved an incentive in such suggestion-box programs. Self-education in such cases is particularly effective because it virtually forces employes to think about safety.

Failure to arouse self education in the program is usually a guarantee that the refinery management is wasting a lot of money and effort.

No safety program in any refinery can ever approach even mild success without the full cooperation of each individual employe in the safety education procedure. It should be as important a part of the planning as any other phase and should be so established from the very first moment any step is taken toward drawing up such a safety education program in the refinery.

When this has been done no refinery executive will be complaining to his wife at the supper table about the indifference of the men to the "brain child" into which he has put so much sweat and tears. He is much more certain to be bringing her home daily fact reports on how well the men are taking to the idea and putting it over! # #

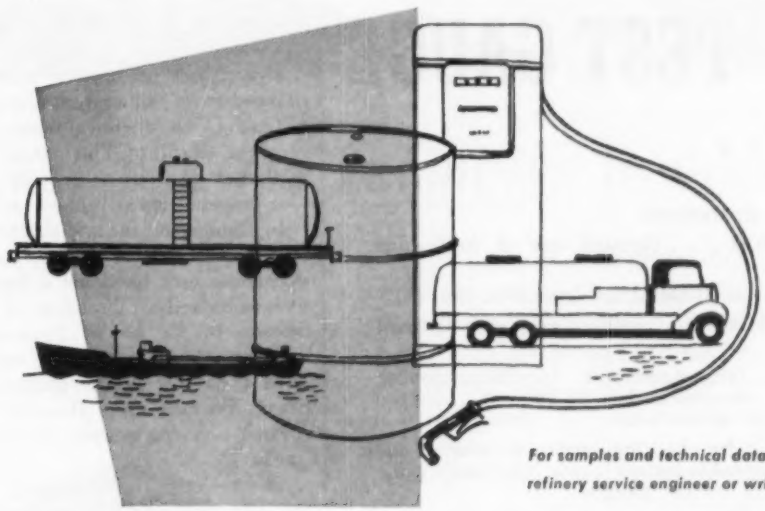
For more data on advertised products, use Readers' Service Cards, last page.

KUPLEX
METAL DEACTIVATOR

A New Tretolite Company product

INSURES BETTER, MORE STABLE REFINED PRODUCTS

Copper contamination of refined products can result from as little as 0.028 mg. of copper per gallon. Copper contamination often results from copper treating, but flow through copper or copper alloy equipment also can result in potentially harmful contamination. Further sources of contamination, pipelines, pumps, tubing and fittings can contribute to copper contamination even after the hydrocarbon product has left the refinery for distribution. Kuplex offers the refiner a method of product quality protection at a minimum cost. Kuplex nullifies, by a chelating action, the catalytic degenerative oxidation caused by copper in hydrocarbons. Especially applicable to gasoline, Kuplex is also effective in hydrocarbon streams such as kerosine, jet fuel, diesel and burning oil, turbine oil and greases.



For samples and technical data, ask your Tretolite refinery service engineer or write to

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A DIVISION OF PETROLITE CORPORATION

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KU-3

Looking for DEPENDABILITY?

the new USG TEST GAUGE assures you . . .

- ¼ OF 1% ACCURACY . . . guaranteed.
- MINIMUM PARALLAX ERROR . . . through use of knife-edge pointer and mirrored dial.
- HIGH SENSITIVITY . . . from an all-metal, low-inertia movement.
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- EXTRA DURABILITY . . . fatigue-resistant beryllium copper Bourdon tubes used for pressures as low as 100 psi . . . longer continuous service between calibrations.

AND IT'S VERSATILE . . . use it for checking service gauges . . . for test cells and panels . . . for portable testers . . . for laboratory work not requiring readability of 12" or 16" gauges.

IT MATCHES . . . available with matching standard back or front flange SUPERGAUGE case design.

Ask for bulletins on Test Gauges . . . the Fig. 1404 above supplied in 4½", 6" and 8½" dial sizes, or, companion test gauges from 3" portable to 16" laboratory units.

UNITED STATES GAUGE

Division of American Machine and Metals, Inc.
Sellersville, Pa.

USG
Home of the SUPERGAUGE

Baytown Refinery

Continued from Page 123

verted from molybdenum- to platinum-catalyst operation during the year, and a new unit was built to use platinum catalyst. These units, each with a daily capacity of about 18,000 barrels, are used to upgrade motor gasoline and supply aviation gasoline blending stocks, raw materials for petroleum solvents and feed stocks for petrochemical operations.

A bauxite-desulfurization unit was built for use with the catalytic reformers. This new unit, with a 30,875-barrel-a-day capacity, removes almost all sulfur from the feed to the Hydroforming units in the form of hydrogen sulfide.

During the year, Humble also placed in service a new unit to treat solvents with clay instead of acid, deresining facilities to eliminate acid treatment of lube base stocks, and Hydrofining units for hydrogen treating instead of acid treating of motor gasoline, heating oil, and lube oils. By-product hydrogen from the catalytic reforming units is used in the Hydrofining operations. Sulfur is partially removed from the Hydrofined products in the form of hydrogen sulfide.

By-product hydrogen sulfide recovered from refinery gases is sold to a Gulf Coast chemical concern for recovery of sulfur. This company has a plant adjacent to the refinery and also processes spent refinery acids.

By eliminating the acid sludge which was burned in the boilers, the new deresining unit has gone a long way in helping reduce discharge of sulfur dioxide to the air at Baytown. In addition to eliminating the need for acid treating at the propane-lube plant, the unit gives Humble better control over the quality of lube base stocks.

The tower in the deresining unit is the heaviest unit of its kind ever erected in one piece. It topped the scales at 306 tons, is 84-feet-tall, 13½-feet in diameter, and has steel walls three-inches thick. The tower was fabricated in Houston; shipped to Baytown on a special flatcar hookup, and lifted into position with four 140-foot gin poles. The job took four days.

Petrochemical Additions—In petrochemicals, Humble acquired in

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THIS IS ONE OF FOURTEEN specialized engineering groups at McKee. Modern, well-equipped quarters are completely air-conditioned. Additional facilities for our expanding organization will be provided in a new two-story building now under construction.

McKee *has the Engineers* to design your plant

● In these days of competition for engineering talent, McKee can supply the services of a large, experienced organization that is well-qualified to design your new plant.

McKee designs and builds blast furnaces, steel plants, petroleum and chemical processing plants, ore preparation facilities and industrial plants. This wide diversification of activities and our fifty-year record of successful, world-wide operation are among the factors which attract top engineers to McKee. Our large staff grows steadily and we continue to welcome applications of qualified men in many fields.

For you, this adds up to an experienced organization capable of undertaking your new plant project promptly and efficiently regardless of size or location.

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engineered
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The heat transfer and process units shown are only a very few of the many designed and fabricated by Manning & Lewis Engineering Co. every year.

This confidence *must* be warranted:

Our customers have proof, from long association that their heat exchange and process equipment will be:

DESIGNED
. . . for Top Quality Performance

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FABRICATED
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These claims are for *US* to prove! Send us your next job for quotation.

We are accustomed to working with all ferrous and non-ferrous metals.

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32 Ogden Street Newark 4, New Jersey
SALES REPRESENTATIVES IN PRINCIPAL CITIES

As Management Sees It . . .

April, 1955, the Butyl-rubber and petroleum-butadiene facilities it was operating for the government. Both these facilities, built in 1943, will be expanded, and the company already has contracted for construction to increase capacity of the butadiene plant by about 16,000 tons a year.

As the initial part of its postwar expansion program, Humble bought the government-owned process equipment at Baytown Ordnance Works to produce quality solvents and components of motor fuel. This purchase, in 1946, gave the company its first Hydroformer (later converted from molybdenum to platinum catalyst operation), a crude-naphtha fractionator (to control both feed and production) and a sulfur-dioxide extraction unit.

The Hydroformer—one of the "hottest" units in the U. S. during World War II—was used in the manufacture of toluene.

With these facilities, Humble is still producing toluene and xylene for solvents and upgrading gasoline, and heavier aromatic solvents; and its petrochemical operations have been expanded to include the production of paraxylene. A low-temperature crystallization unit has been installed which now is turning out paraxylene of better than 98 percent purity. This high purity paraxylene is being used by another company to make Dacron.

A super-fractionation unit was built during the war for preparing aviation-gasoline blending stocks from virginia naphtha fractions. This unit is fractionating, in blocked operation, part of the polymer from the new catalytic-polymerization unit to make tripropylene and tetrapropylene (C_9 and C_{12} olefins, respectively). These olefins, used in manufacturing high molecular weight alcohols and synthetic detergents, are sold to other companies for further processing. Narrow boiling range aliphatic solvents, also produced by super fractionation, are 10-degree hexane, 10 degree heptane, 10-degree octaine, low-boiling solvent naphtha mixtures, and cleaner's naphthas.

Cyclohexane of 85-percent purity has been and is now again being produced at Baytown, and the possibility of making high purity cyclohexane, benzene, orthoxylene and ethylene is being studied. The company

For more data on advertised products, use Readers' Service Cards, last page.

The Economical Solution

for BLENDING LIQUIDS • DISSOLVING SOLIDS IN LIQUIDS
MIXING GASES WITH LIQUIDS • AERATING • GASIFYING • OPERATED IN
ANY TYPE OPEN OR SEALED VESSEL

Struthers Wells

RADIAL PROPELLER Agitator

Agitator drives range in speed from 10 RPM to 500 RPM; from fractional to 50 h.p. with stuffing boxes or mechanical seals for pressures up to 500 pounds or more.

Quick opening manhole for inspection or filling.

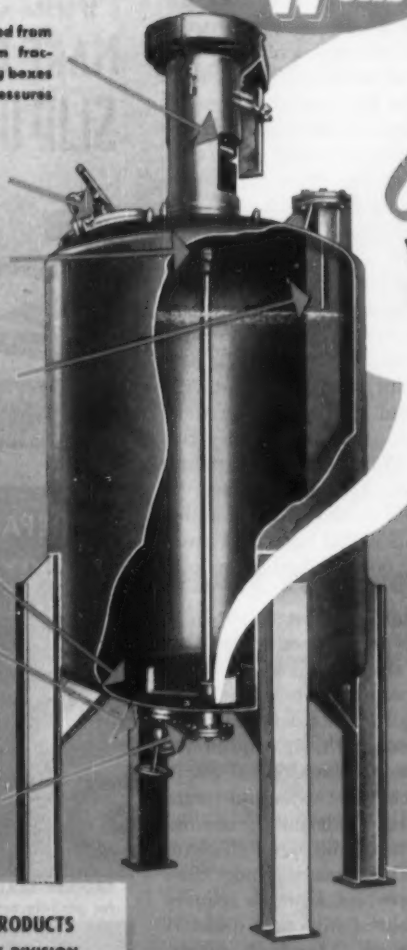
Semi-flexible coupling protects shaft bearings from bending movements.

Vertical baffles supported by a nozzle in the top head eliminating pockets in which materials may accumulate and providing easy outside adjustment.

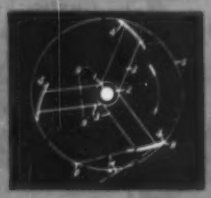
Radial propeller agitator is simple, efficient and self-cleaning.

Struthers Wells flush bottom valves are available in several sizes and materials.

Removable bottom guide bearing simplifies maintenance.



The peripheral angle of the blades can be made to meet any requirement.



The illustration at left shows the Struthers Wells Radial Propeller Agitator mounted in a heavy-duty stainless steel mixer. Radial Propeller Agitators are available in all commercial sizes and materials, and can be specifically designed for any practical liquid agitating requirement.

Write for Bulletin 58-W

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Crystallizers . . . Direct Fired Heaters . . . Evaporators . . . Heat Exchangers . . . Mixing and Blending Units . . . Quick Opening Doors . . . Special Carbon and Alloy Processing Vessels . . . Synthesis Converters

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WARREN, PA.

Plants at Warren, Pa. and Titusville, Pa.

Offices in Principal Cities

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GOV'T. METHOD 3703 and ASTM D-1319 F.I.A.

(Fluorescent-Indicator Adsorption)

ULTRA - VIOLET Model X-40 . . . single tube, 3650 Angstrom units, length 49" overall, 40 watt. For 110 volts A.C.

$44.75 COMPLETE

Also Complete Range of Ultra-Violet Sources . . . 3660 A.U. and 2537 A.U. available in laboratory, industrial, and portable models.

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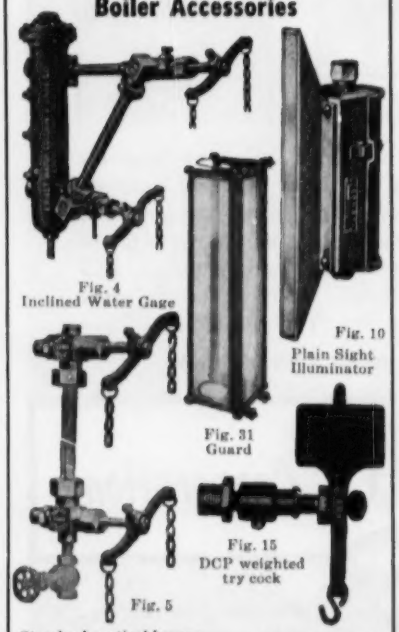

Fig. 4 Inclined Water Gage

Fig. 10 Plain Sight Illuminator

Fig. 31 Guard

Fig. 15 DCP weighted try cock

Fig. 5

Standard vertical bronze water gage, 350 pound

Send for Catalog

ERNST WATER COLUMN & GAGE CO.
Livingston, N. J.

As Management Sees It . . .

also is turning out some durene in 70,000 pound batches in the low temperature crystallization unit for another concern to use in development work. This product is testing out 98- to 99-percent pure.

Other Facilities—All the while, Humble was making changes in its facilities for storing, handling and shipping petroleum and its products by tanker. New pipe lines were built to the docks; a large new dock was added on the Houston Ship Channel opposite the refinery, and new storage tanks were built in the dock area. Because of the large number of processes employed at Baytown and the many product streams involved, Humble maintains approximately 1000 oil and chemical tanks having a combined capacity of some 24 million barrels.

To step up loading, since some 75 percent of Humble's refined products move out by tanker, the docks were equipped to move more than 100,000 barrels an hour, loading as many as six tankers and six barges at a time. These facilities were used early this year to load 13 tankers and 19 barges in three days. The total volume of cargoes loaded during this three-day period was 1,959,282 barrels of gasoline, heating oil, jet fuel, lube oils, and crude.

One structure built at Baytown in the past ten years covers nearly four acres. This is the Central Shops building. Today, nearly all the plant's mechanical crafts are housed under one roof in this mammoth, air-conditioned building. Outside the Central Shops building, mechanical tools and methods have been modernized, streamlined, made faster and more efficient.

Early in 1951, climaxing more than 25 years of progress, Humble refinery researchers moved into new quarters in the Baytown Research center. Everything in it is designed for comfort and convenience at work, as well as for more efficient operations. But already times have changed, and Humble has started an expansion of this building too.

The number of patents issued to Baytown technical personnel is a measure of the progress made in Humble's refinery research. Between 1932 and 1944, some 60 patents were issued. Between 1944 and 1954, a total of 416 was issued. ##

THE BERGMAN Safty-Spanner

a helper you can trust

MADE OF THE TOUGHEST ALUMINUM-MAGNESIUM ALLOY

WILL NOT DAMAGE VALVES
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MAKE BURRS
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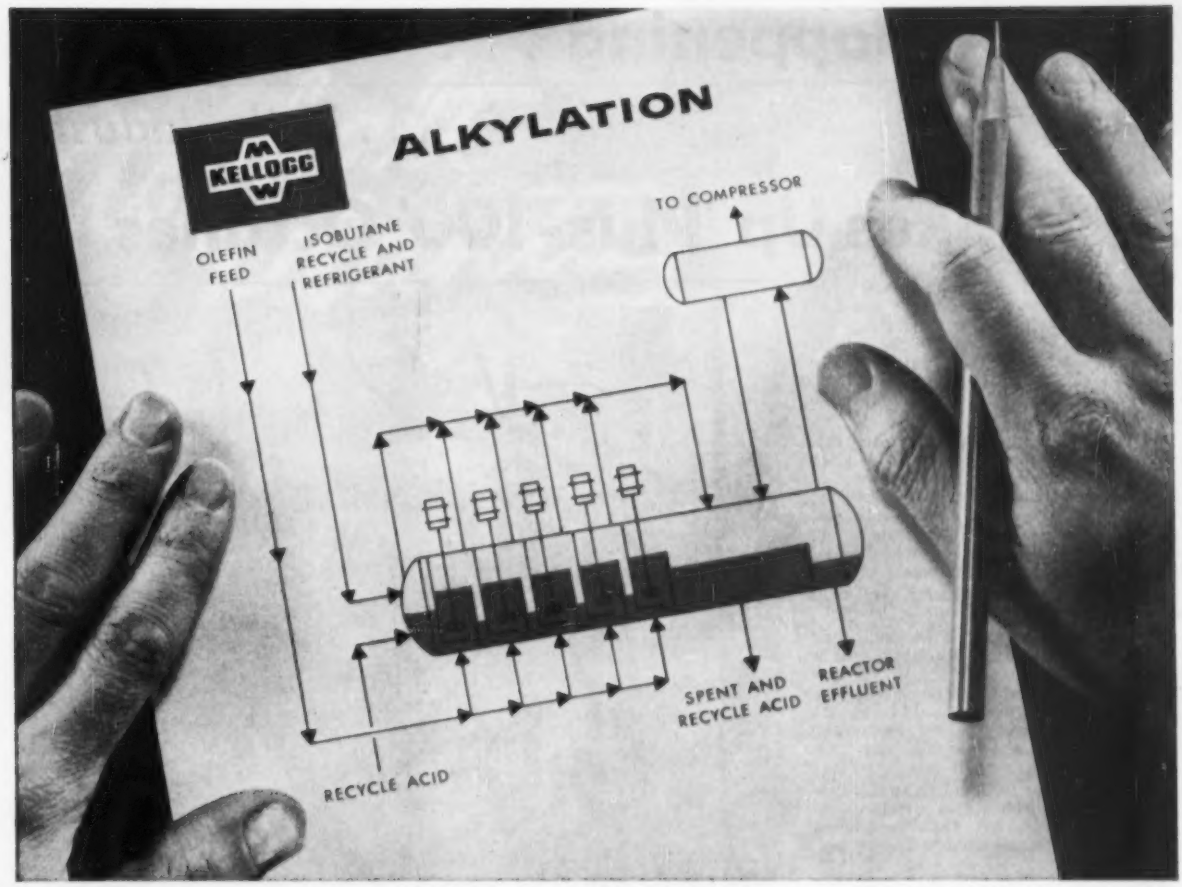


Lower Investment in Recycle Equipment with Multiple Stage Cascade Reactor

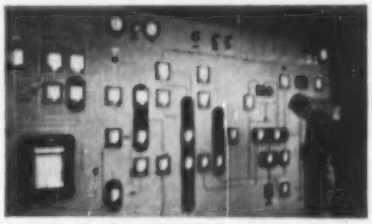
With more and more refiners expanding their alkylation capacity, attention is focussed again on the equipment economy and isobutane efficiency of M. W. Kellogg's cascade reactor as compared with earlier jet-type systems.

In a 2,500 BPD alkylation plant, for example, Kellogg's five-stage design reduces the number of reactors required from four to one! Instead of the approximate 12,800 BPD of isobutane recycle needed for the four individual reactors, Kellogg's single reactor requires only 4,500 BPD recycle!

In addition, the isobutane tower is reduced from 13½ to 7 feet in diameter. Exchangers, condensers, reboilers, pumps, piping, and other auxiliary equipment are proportionately smaller. And one centrifugal compressor replaces three reciprocating machines.

M. W. Kellogg welcomes the opportunity to discuss with you the improvements it is continuously making in its alkylation techniques. Recent examples are a cascade reactor with *seven* reaction zones, and the new bauxite process—developed jointly with D-X Sunray Oil Company—which reduces corrosion and fouling of fractionating units.

A recent installation of M. W. Kellogg's sulfuric acid alkylation process clearly shows the unique cascade reactor.



Control panel for units shown in the other photograph, with instruments identified by color-coded silhouettes.

Refinery Process Division

THE M. W. KELLOGG COMPANY

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What's Happening . . .

. . . in the Industry

API Takes Up 'Plus-100' Octanes

The problem of expressing octane numbers above 100 was taken up by the API Division of Refining at its midyear meeting in Montreal. Three papers on the subject were presented at a joint session of the institute's Committee on Petroleum Products and its Automotive Research committee.

T. B. Rendel, with Shell Oil Company, presented various proposals for extending the octane-number scale; L. W. Moore, of The American Oil Company, discussed the economic importance of octane numbers, and B. B. Turner, with Ethyl Corporation, discussed the importance of octane numbers in terms of engine performance.

There seemed to be general agreement on at least three points:

- A decision on a scale for indicating antiknock quality above 100 octane is long over-due.
- The most suitable reference fuel (the system on which this should be based) is isooctane and heptane up to 100 octane level, and isooctane and TEL above 100 octane.
- There appear to be no technical difficulties in selecting and standardizing such a scale, but the one chosen should be proportional to engine performance.

Expressing the refiner's viewpoint and his company's own attitude on the subject, Moore said that the performance number gives a good indication of both available power for the consumer and cost of quality to the refiner.

"It should represent a satisfactory basis for standardization above 100 octane, although it must be recognized that such a move will cause the technical people in their refinery work and in publishing technical papers to use performance numbers below 100 as well.

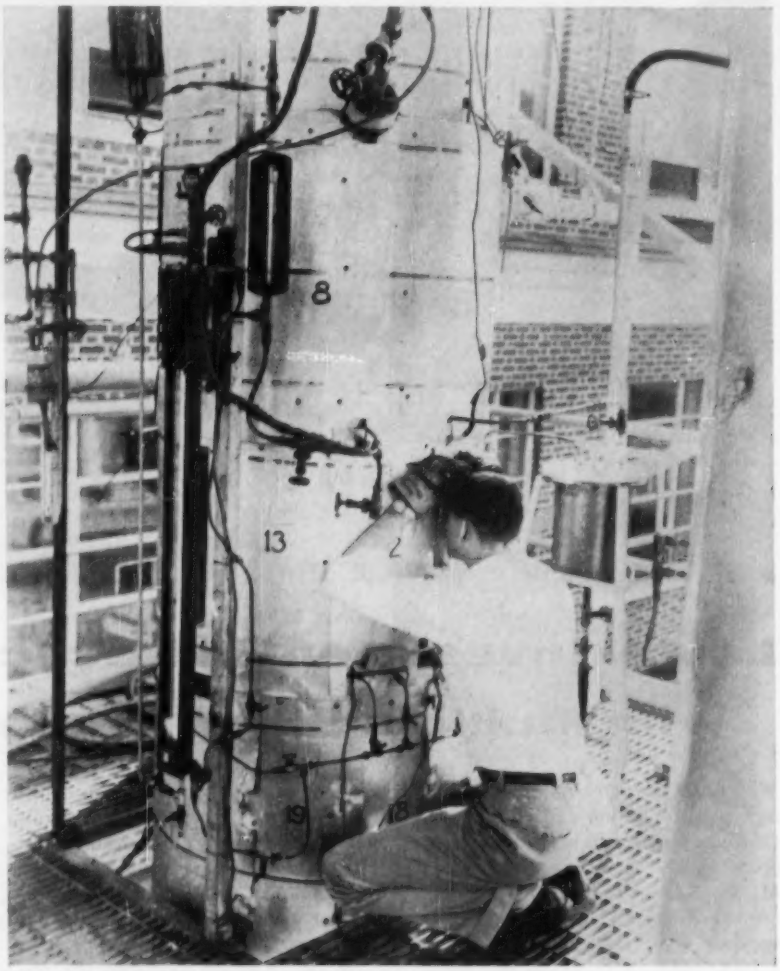
"In addition, our efforts should be intensified on the development of an improved method for measuring antiknock quality above 100 octane number regardless of whether this requires a new fundamental approach to antiknock rating or merely refinement of the present methods," he said.

Giving the viewpoint of the automobile industry, Turner emphasized that the scale extension selection is of much less importance to the automobile industry than to the refining. But in general:

"The automotive industry believes that an octane scale extension above 100 is needed in the very near future. The proposed extension, 100 PN — 100, is a satisfactory compromise, although two of the three major auto manufacturers would prefer that PN be used for rating both above and below 100," he stated.

But whatever is decided, according to Turner, antiknock value well above current levels can be used to an advantage by engines of increased compression ratio.

A companion problem emphasized frequently during the discussion in Montreal was the necessity of improving the precision of octane-number determinations.



Researchers at the University of Delaware are using a 15-foot-high distillation column for experiments in plate efficiency. The column, two-feet in diameter, contains five buddle trays.

AIChE Joins in Campus Research

Experiments on the effect of operating and design variables of distillation and absorption columns upon plate efficiency are nearing completion at the Newark, Del., campus of the University of Delaware under the guidance of Jack A. Gerster, professor of chemical engineering. The investigations, initiated and under the direction of the Research committee of the American Institute of Chemical Engineers, are being sponsored and underwritten by 33 industrial firms.

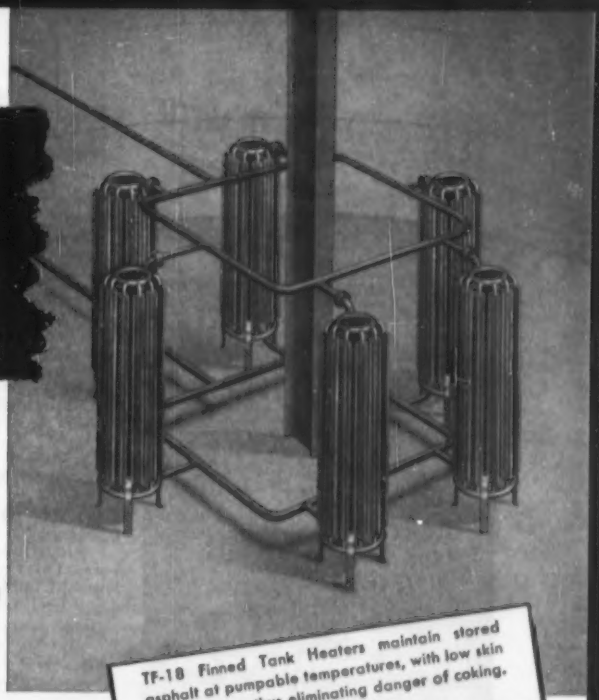
The work is being conducted through the use of a 15-foot-high experimental distillation column, which is unique because of several features incorporated into the design to insure that accurate plate efficiency measurements can be made under commercially important conditions.

A column diameter of two feet was decided upon to eliminate wall effects and make the results applicable to commercial units. The column contains five bubble trays which can be adjusted in increments of six inches to give tray spacings of from one to two-and-a-half feet.

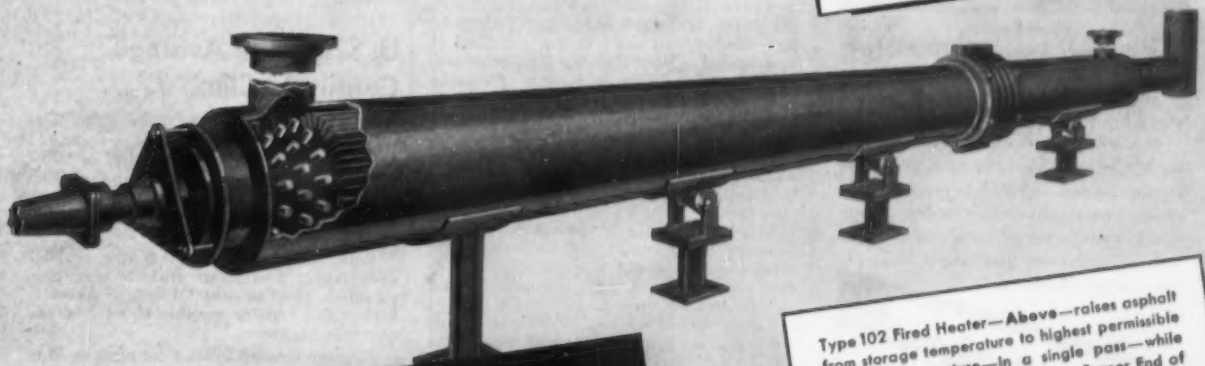
Built for a working pressure of 125 pounds per square inch gage, the unit also

Asphalt Plants

load out faster at higher temperatures... serve a wider area...

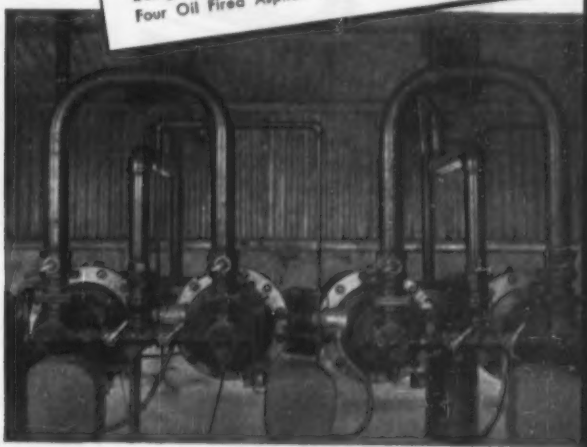


TF-18 Finned Tank Heaters maintain stored asphalt at pumpable temperatures, with low skin temperatures, thus eliminating danger of coking. Vertically mounted. Self cleaning.



Type 102 Fired Heater—**Above**—raises asphalt from storage temperature to highest permissible loading temperature—in a single pass—while being pumped to trucks. **Below:** Burner End of Four Oil Fired Asphalt Heaters.

with Brown Fintube



TF 18 Tank Heaters and Type 102 Fired Heaters

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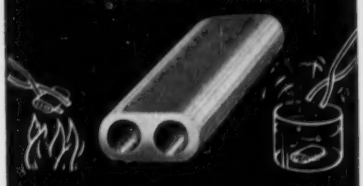
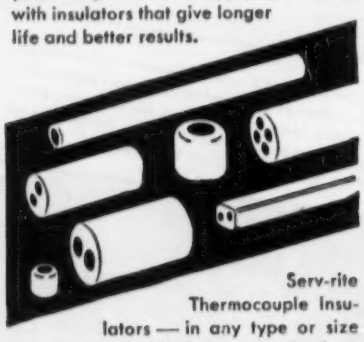


This Gordon Thermocouple Insulator, heated red hot and plunged into cold water, came out just as good as new

Available only through GORDON, Serv-rite Thermocouple Insulators are made to stand the gaff of excessive thermal shock far above normal requirements.

For sturdy and reliable thermocouple insulator performance to meet peak production needs—specify Serv-rite . . . a development backed by Gordon's many years' experience in supplying industry with insulators that give longer life and better results.



Serv-rite Thermocouple Insulators — in any type or size — can be supplied immediately from Gordon's large stocks in the Chicago and Cleveland plants. Remember — you can always distinguish Serv-rite Insulators by their tan color.

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Asbestos Tubing
Double Hole Round
Asbestos String
Single Hole
Double Hole Oval

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What's Happening . . .

can operate under vacuum (20 inches of mercury). Special equipment allows the sampling of vapor and liquid during the operation and permits window-observation of bubble tray action.

The problem of correlation and prediction of plate efficiency was chosen for study by the Research committee of the AIChE not only because they believed this problem to be of importance to many types of chemical industries, but because the problem required substantial group effort to overcome its complexities.

New Hawaiian Refinery May Take Act of Congress

Government has agreed to give Standard Oil Company of California tax help on $32 million worth of petroleum-refining and alkylation facilities for its proposed refinery in Hawaii.

But the company may have to wait on an act of Congress for authority to start construction of the 30,000-barrel-a-day plant.

Originally, it was believed that title to the proposed refinery site on Sand Island in Honolulu Bay could be transferred from the Army to the territorial government by Executive order, since it was acquired in that manner. Now it seems legislation will be the only solution in view of a complicated title to the land.

When the island was taken over by the Army, it was only a reef in the harbor. Since then it has been filled in to the mainland, posing a problem of submerged lands apparently not covered by any specific law.

Legal opinions from various government agencies on the status of the island are needed before legislation can be considered to clear the way for sale of the island to California Standard.

Views are being sought from the Justice and Interior departments and from the General Services Administration. Once established that normal transfer would not be feasible, legislation will be sought to transfer Defense Department jurisdiction over the island to the territory, which then could dispose of it as it saw fit.

Local and territorial governments already have approved zoning and sale of the land at public auction.

Rapid tax amortization on the proposed plant from the Office of Defense Mobilization is a financial matter which has no bearing on the problem of proper title to the land.

The company will be allowed 65 percent on $12,461,000 for basic refining facilities, 100 percent on $1,784,000 for an alkylation unit, 45 percent on $16,883,000 for auxiliary equipment, and 15 percent on $962,000 for buildings. It was not allowed tax amortization on $4,110,000 for the project.

Facilities will include distillation, catalytic cracking, alkylation and sulfuric-acid-plant processing equipment.

Lehigh Receives Grant

Lehigh University has received a grant of $1750 from The California Oil Company. An unrestricted award of $1000 was given for use by the Department of Chemical Engineering, and a $750 undergraduate scholarship in chemical engineering will be established at Lehigh in September.

Sees Jet-Fuel Needs Soaring in Four Years

An increase of 150 percent in jet fuel production will be necessary to meet rising military and commercial aircraft needs within the next four years, according to W. S. Mount, chairman of the American Petroleum Institute's Aviation Technical Service committee, and one of the speakers at the A.P.I. Division of Marketing mid-year convention at Atlanta.

One of the large airframe manufacturers predicts a 100 percent increase in air traffic during the next six years, Mount, who is with Socony Mobil Oil Company, told the convention. This estimate was made in view of the increase which has characterized the trend of business recently, and the passenger-generating capacity of the new aircraft designs which will soon make their appearance.

"Last year the 4765 aircraft of the free world airlines, plus military and all other, used 287,000 barrels a day of gasoline," Mount said. "An additional 350 gasoline engine aircraft are on order. The additional airline consumption will make itself felt over the next several years, more than compensating for any loss of military volume in that time, and tending to hold overall gasoline volume at about the 1956 level up to 1965."

U. S. Octane Average Continues Climb

In a broad nationwide advance, gasoline on sale at service stations in May increased to national weighted averages of 96.7 octane number for premium and of 89.7 octane number for regular, according to the latest survey compiled by Ethyl Corporation.

Both grades gained 0.4 octane number over April. Compared with a year ago, premium gasoline was 1.4 octane numbers higher and regular gasoline was 1.7 octane numbers higher.

Average tetraethyl lead contents in May were 2.56 ml per gallon of premium gasoline and 2.30 ml per gallon of regular gasoline.

Forty-four of the 53 cities covered by Ethyl's survey reported increases over April in the average octane number of their premium gasoline, with 20 cities showing a monthly gain of 0.5 octane number or more. Seven cities reported decreases while two cities were unchanged. In regular gasoline, 36 cities reported increases in their average antiknock quality, 16 of them by 0.5 octane number or more. Thirteen cities reported decreases while four cities were unchanged.

Alkylation Goal Still Undetermined

One of the big industry questions in Washington last month was whether the government would extend its alkylation goal.

On the one hand, there were strong indications that the goal would not be extended—despite the fact that applications for rapid tax amortization now on hand far exceeded the last 25,000-barrel-a-day goal established.

On the other, there were reports that some government oil planners doubted the wisdom of ending the write-off program

PETROLEUM CHEMICALS DIVISION

NEWS

June ★ One of a Series of Bulletins for the Petroleum Industry ★ 1956

In This Issue . . .

1. YOU'LL BE INTERESTED in the new dry-dye eduction probe developed by Du Pont. It's described at the right.
2. HOW CAN *YOU* use the Du Pont automotive service discussed below to promote better relations with your large commercial fleet customers?
3. IF YOU HAVE a refinery in the Chicago area, you'll want to know Dr. Neal Lawson and how he can help you make the most efficient use of additives. See next page.
4. THE MOVIE is one of the most valuable of modern sales promotion and training tools. There's an article on the next page about four Du Pont movies produced to help you in your sales, training, and public relations.

They can help you turn complaints into sales

Our Du Pont automotive specialists have more than just faith in the high quality of your fuels and lubricants. They're always prepared to help you *prove* your quality story.

For example . . .

The operator of a fleet of tractors and other gasoline-powered farm equipment, complained about excessive valve burning. He was quite emphatic about blaming the trouble on fuel quality. And he had practically made up his mind to change suppliers when the oil company representative, accompanied by a Du Pont automotive specialist, arrived on the scene to investigate the trouble.

An impartial third party, the Du Pont man was able to convince the rancher that the fuel was not the real source of the trouble . . . but rather that it was the result of tractor operators tinkering with the air-fuel mixture ratio.

This is only one of many cases in which oil companies have been able to turn complaints into good will with the help of a Du Pont automotive specialist.

Our men often accomplish this through the use of the Du Pont fleet of fuel test cars, our single-cylinder demonstration engines and chassis dynamometers – in addition to their own wide experience in solving automotive problems involving the use of fuels and lubricants.

The services of these Du Pont automotive specialists are yours for the asking. And you can get in touch with one of them through any of our sales offices listed in the signature of this ad.

Faster, cleaner, easier gasoline dyeing now possible with new eduction development

A revolutionary new dry-dye eduction probe, developed by Du Pont engineers, can make gasoline dyeing a cleaner, faster and more efficient operation. The device, although simple in design, offers six distinct advantages over other gasoline-dyeing methods . . .

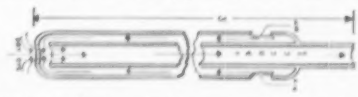
HERE IS a typical setup for using the new Du Pont Dry-Dye Eduction Probe. A short neoprene hose makes possible a permanent, yet completely flexible coupling.

1. "Dusting" is reduced. Exposure of operator and area to dye is minimized. Cleanup time is saved.
2. No plugging of the probe, hence no interruption of the dyeing process. No time loss for clearing plugged probe, and cleanup of area afterward.
3. Dye from the shipping drum can be introduced directly into the finished gasoline. Thus the step of pre-dissolving, required by some systems, is eliminated.
4. Minimum of operating skill required.
5. More pounds of dye are transferred per minute.
6. Minimum investment in space and equipment, considering the cleanliness of operation achieved.

Design and Operation

Conventional probes are little more than pipe sections, some with modified tips. Dipped into the drum, these probes suck up dry dye and pass it into the gasoline system. They are relatively inefficient, however. Extreme care is required of the operator – yet clogging is still likely to occur from time to time. This means interruption of the dyeing process – both to clear the probe and to clean up the area.

In many field tests and under varied conditions, the new probe has been found to be clog-proof, due to its



unique design. It is an aluminum tube within a larger one. The inner tube,

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OVER

PETROLEUM CHEMICALS DIVISION
NEWS

CONTINUED Eduction Development

like the earlier probe itself, transfers the dye from drum to main system. However, the outer tube supplies a down-draft of air, controlled by two adjustable ports at the head end, which insures continuously fluidized flow of dry dye that is uninterrupted by clogging. This feature is an important time-saver.

Dyeing Speed

The new eduction probe makes possible faster dyeing. Tests in units currently in use show speeds ranging from 18 pounds per minute for Du Pont Oil Orange to 40 for Du Pont Oil Red.

The Complete Eduction System

The principal factors responsible for the successful operation of a complete dry-dye eduction system are:

1. Adequate air handling capacity
2. Proper suction-line design
3. The probe described above

A smooth line from the mouth of the probe to the eductor is essential to avoid plugging. The dye probe should be permanently coupled to a short length of neoprene hose. The entire line from the mouth of the probe to the eductor should be of 1-inch inner diameter and completely unobstructed. It should be as short as possible, preferably not over 10 feet. The shut-off valve employed should be of a type permitting full-round flow. Pressure gages guide the operator.

Eduction systems can be used to transfer other fine crystalline materials as well as dry dyes; for example, Du Pont Gasoline Antioxidant No. 29.

However, for the transfer of *liquids* – such as Du Pont Metal Deactivator and Gasoline Antioxidants Nos. 5 and 22 – a separate eduction system should be used. Use of the same system, first for a liquid, then for a dry product, might result in clogging caused by residual liquid in the line.

Low-cost Installation

Your present dyeing facilities can probably be modified to utilize the features of this system at relatively low cost. A Du Pont Petroleum Chemicals Division representative will be glad to study your present system and make appropriate recommendations.

REGIONAL ADDITIVES SALES MANAGER

DR. NEAL D. LAWSON was recently appointed to the newly created post of Additives Sales Manager of the Du Pont Petroleum Chemicals Division's Central Region.

With headquarters in the Chicago office, he is in charge of sales and technical service work for all Du Pont additives other than tetraethyl lead. This includes Du Pont Metal Deactivator, lube and fuel oil additives, antioxidants, dyes, and grease stabilizers.

Prior to this assignment, Dr. Lawson was head of the chemical division of the Du Pont Petroleum Laboratory. He had previously been supervisor of the Laboratory's lube oil group.

Before joining the Du Pont Company in 1947, he was Research Assistant and Instructor in Petroleum Refining at Pennsylvania State University. His work there included research on the oxidation of lube oils, the influence of refining procedures on oxidation, and development of additives for lube oils.

Dr. Lawson is a chemical engineering graduate of Pennsylvania State College, where he also received his M.S. and Ph.D. degrees. He is a member of the American Chemical Society and Society of Automotive Engineers.

These Du Pont movies help promote your on-the-move industry

During recent years, audiences estimated at well over a million people have seen these four Du Pont-sponsored movies promoting your industry.

What Makes a Gasoline Good, a full-color cartoon movie, explains graphically and convincingly how refiners tailor gasoline quality to motorists' needs. Since the film's release, the Du Pont Petroleum Chemicals Division has made available to oil companies a total of 249 prints.

Pipeline on Wheels shows how gasoline tank trucks are made and operated for maximum highway safety. One hundred and seventy-five prints of this film have been made available for oil industry use. For 52 of them which were purchased and distributed directly by oil companies, we have no audience records. But the remainder, distributed by Du Pont on a loan basis, were seen by more than 61,000 people.

A total of 395 prints were made of the Du Pont movie, **It Never Rains Oil,** which tells the story of percentage depletion. Reports indicate that this film is doing an excellent job of creating a better understanding of this important issue.

The newest movie in the series is entitled, **When the Customer says "KNOCK."** It explains – for the benefit of service station operators and customer groups – the many mechanical and atmospheric factors (other than gasoline quality) which contribute to knock.

Prints of these films are readily available to you on a loan or purchase basis. Address your request to any of our sales offices listed below.

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A-2071

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What's Happening . . .

for alkylation plants—despite the fact that the industry probably would go ahead with its expansion plans without special tax grants.

Oil planners in the Interior Department and the Office of Defense Mobilizations were pointing to the industry trend to expand alkylation facilities for stepping up the octane ratings of motor gasoline.

Some did not seem to think the end of tax write-offs would effect this expansion. Others felt some safeguards should be taken against the possibility that in building to meet peacetime requirements for higher-octane motor gasoline industry might not build enough to meet possible wartime needs.

Meanwhile, the Armed Services Petroleum Purchasing Agency will continue to pursue its facilities-contract program, under which is guaranteed alkylation offtake and agrees to make proper compensation for facilities put on standby. Prices under this program are negotiated.

ASPPA sources said the agency is approaching its goal, but that it will consider proposals for new contracts in any area. Emphasis, however, is now on the Pacific Northwest.

Should the alkylation program be closed, ODM is expected to lay down rules on how applications on hand would be processed. Presumably, they would be taken up on the basis of first come, first served.

Union Carbide to Buy Last Government Unit

Rubber Producing Facilities Disposal Commission has reached an agreement with Union Carbide and Carbon Corporation for the sale of the government-owned alcohol-butadiene plant at Louisville, Ky., for $3,125,000.

This is the last of the 27 government-owned rubber-producing facilities which the commission was authorized to sell.

The sale is expressly subject to a lease between the commission and Publicker Industries, Inc., which expires in April 1958. It will have to be cleared by the Justice Department on antitrust matters and reviewed by Congress.

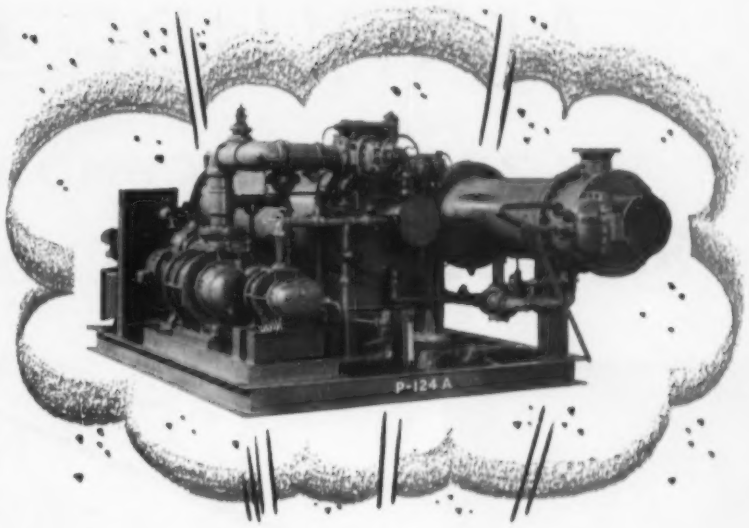
Esso, Humble Introduce Three-Grade System

Two affiliates, Esso Standard Oil Company and Humble Oil & Refining Company, are switching from the traditional system of marketing only two grades of gasoline and introducing a new three-grade marketing system.

The change by Esso Standard was announced after company studies showed a two-grade system no longer the best answer to problems posed by the fast widening range in power requirements of automobile engines. Humble's announcement followed shortly.

Esso was to have changed to a three-grade system in six cities, with plans to extend the new system by mid-August to about 75 percent of the service stations in its 18-state market area. Humble expects to introduce its new third grade in six Texas cities about June 20, later extending the system to other areas in the state.

Among other qualities, the new Esso gasoline differs from conventional gasoline because its altered molecular structure in-



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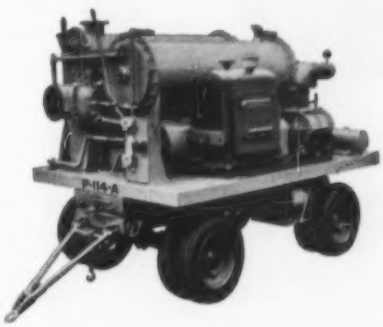
For details on how R-C Inert Gas Generators afford constant, instant protection, just call your nearest Roots-Connersville office or mail the coupon.



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656 Crescent Ave., Connersville, Indiana. In Canada—629 Adelaide St. W, Toronto, Ontario

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Company _____

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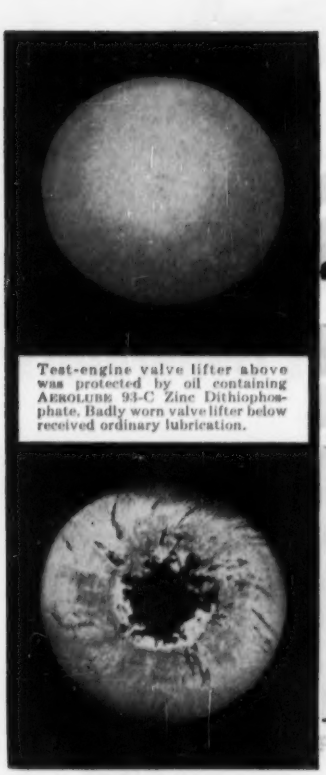
For more data on advertised products, use Readers' Service Cards, last page.

AEROLUBE® 93-C

ZINC DITHIOPHOSPHATE

Fights Wear... cuts engine repair



Test-engine valve lifter above was protected by oil containing AEROLUBE 93-C Zinc Dithiophosphate. Badly worn valve lifter below received ordinary lubrication.

Nine out of ten new cars today are delivered with zinc dithiophosphate in the initial fill or "break-in" oil.

The reason? Major automotive manufacturers have found zinc dithiophosphate the most effective wear inhibitor, particularly in the valve train mechanisms of modern V-8 high-compression engines.

Best of the zinc dithiophosphates is Cyanamid's AEROLUBE 93-C, specially modified to give superior antiwear characteristics. It also controls oil oxidation and checks formation of oil-insoluble sludges and varnishes. It retards formation of peroxides and organic acids that corrode cadmium-silver and copper-lead bearings.

Very light in color, compatible with all lube oil stocks and other additives, AEROLUBE 93-C may be used alone for API Service MM and initial fill requirements, or with detergents such as AEROLUBE 90 for heavy-duty formulations.

Whether you are formulating lube oil for initial fill or day-to-day service, try AEROLUBE 93-C Zinc Dithiophosphate for better control of wear, oil oxidation and bearing corrosion.

CYANAMID

AMERICAN CYANAMID COMPANY
REFINERY CHEMICALS DEPARTMENT
30 Rockefeller Plaza, New York 20, N.Y.

In Canada: North American Cyanamid Limited, Toronto and Montreal

creases its energy content per gallon. For both companies, the retail price of the new gasoline will be 3 cents a gallon above the current price of premium gasoline on sale at their stations.

Meanwhile, Standard Oil Company (Indiana) announced the highest octane grades of gasoline in the company's history were being distributed in its 15-state market area. And to help pay for the new high-level in quality, Standard announced that upward adjustments in prices would be necessary.

Another integrated company advancing its retail prices to help cover the higher cost for improved-quality gasolines was Continental Oil Company.

Monsanto Joins Sonneborn In Developing Miley Process

Monsanto Chemical Company has joined L. Sonneborn Sons, Inc., in the development and sale of acid-sludge decomposition processes of the indirect type.

The process, based on the invention developed by Sonneborn's Hunter Miley (*see* PETROLEUM REFINER, *September 1955, page 138*), is being offered as the Miley-Monsanto-Sonneborn process.

The process recovers sulfuric-acid values present in the sludge and converts the organic portion of the sludge into coke for use in the chemical industry.

The operation is carried on in an apparatus in which the sludge is mixed with hot coke. At a carefully-controlled, relatively-low temperature, the sulfuric acid is converted into a gas of high sulfur dioxide concentration while the organic matter is converted into more coke.

Kerr-McGee to Buy Cushing Refinery

Kerr-McGee Oil Industries, Inc., will buy the 19,000-barrel-a-day General American Oil Company refinery at Cushing, Okla. The price is expected to be about $3.5 million.

Kermac has been operating the Cushing refinery on a lease basis. The lease was acquired when the company bought Deep Rock Oil Corporation, which has been operating as a subsidiary.

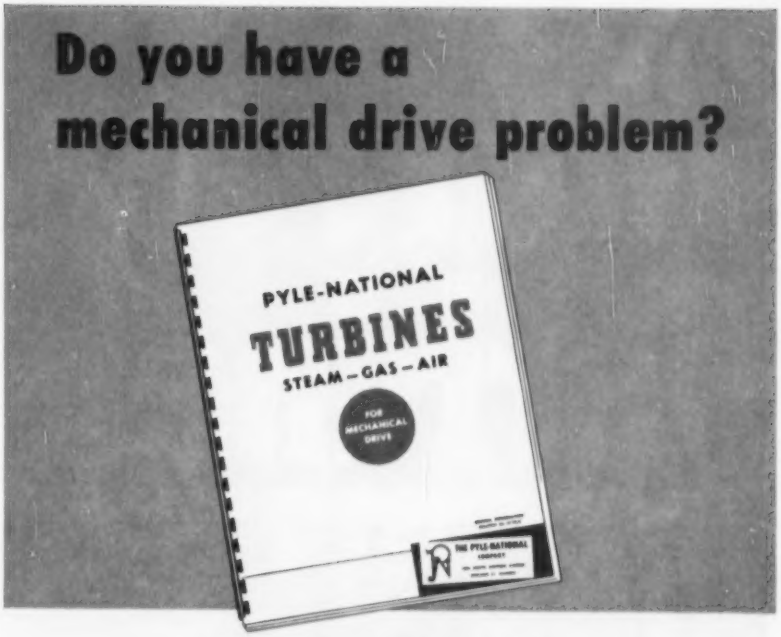
Another Oklahoma refinery which Kermac has agreed to purchase is the 7000-barrel-a-day Gasteria, Inc., refinery at Cleveland. This refinery, formerly owned by Johnson Oil Refining Company, will be bought at a salvage price.

Fluor Gets Safety Award

The Fluor Corporation, Ltd., has been awarded its second straight National Safety Council plaque for no lost-time accidents during a calendar year. Averaging 1237 employes a month, Fluor's main plant in Los Angeles totaled 2,376,890 man-hours without a lost-time injury in 1955.

Refining Profits Up

Petroleum-refining industry gained 8 percent in sales and 13 percent in profits after taxes in 1955. This is information contained in a joint report from the Secu-



TURBINE
SELECTION AND ENGINEERING
DATA BOOK

The most complete reference available to answer your questions on turbines . . . at-a-glance information on speeds, B.H.P., pounds-steam/B.H.P.-hour at various steam pressures.

Request your copy today on your company letterhead.

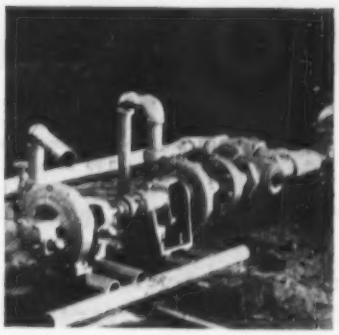
59 years' experience in turbine development

PYLE-NATIONAL TURBINES

¼ to 120 HP for mechanical drive

—the turbines that ask no favors in the refinery or in the field

- Weatherproof!
- Rugged!
- Trustworthy!
- Easiest of all turbines to service and maintain!



Also available: Turbo-Generators (½ to 15 KW)
Turbo-Alternators (60 cycle ½ to 20 KW)

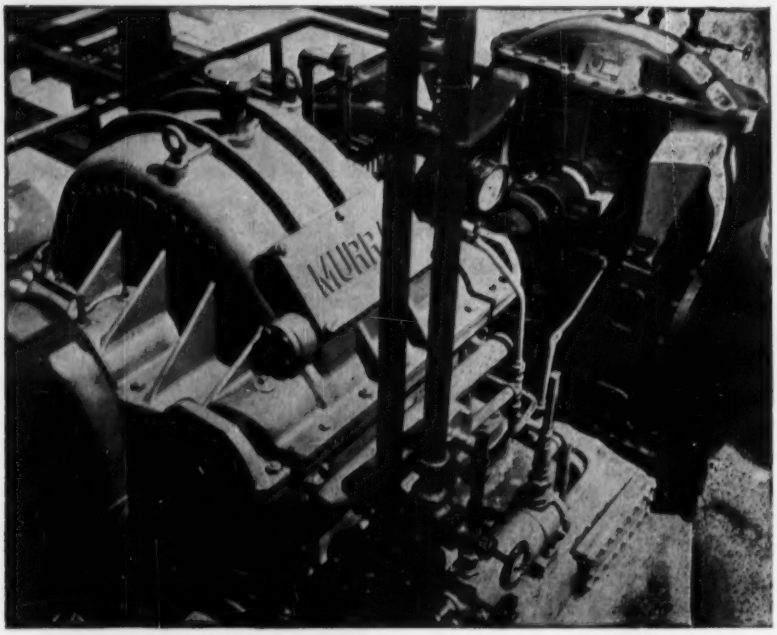
SINCE 1897

THE PYLE-NATIONAL COMPANY
WHERE QUALITY IS TRADITIONAL
1393 N. Kostner Avenue, Chicago 51, Illinois

Branch Offices and Agents in Principal Cities of the U.S. and Canada • Canadian Agent: The Holden Co., Ltd., Montreal • Railroad Export Department: International Railway Supply Co., 30 Church St., New York 7, N.Y. • Industrial Export Department: Rocke International Corp., 13 E. 40th St., New York 16, N.Y.
CIRCUIT CONTROLS • PLUGS AND RECEPTACLES • LIGHTING FIXTURES • FLOODLIGHTS

For more data on advertised products, use Readers' Service Cards, last page.

Murray Turbines



One of 4 Murray type U turbo-gear units installed in a southwest rubber plant still giving trouble free service after 12 years in an unprotected outdoor location. This unit drives an Induced Draft Fan requiring 425 HP at 683 RPM. The turbine speed is 3500 RPM.

● Murray turbo-gear units for mechanical drive are right at home in difficult outdoor installations. Fans, pumps, compressors, and many special types of slow speed machines are among the long list of installations powered by Murray turbo-gear units.

Murray gears are of the Herringbone or Double Helical type and all are pressure lubricated at the point of tooth contact.

MURRAY IRON WORKS COMPANY
BURLINGTON, IOWA

Builders of Steam Power Equipment for Three Quarters of a Century

What's Happening . . .

rities and Exchange Commission and the Federal Trade Commission.

Industry sales for the year were $22.8 billion, as against a little more than $21 billion in 1954. Profits after taxes were nearly $2.53 billion in 1955, compared to $2.23 billion in 1954.

Louisiana ACS Sets Manpower Program

American Chemical Society's Louisiana section has taken the importance of industrial growth and the shortage of technically-trained personnel as the theme of its meeting to be held in New Orleans October 11-13.

As part of its program, the section will try to spur interest in science among high school students by sponsoring a contest for the best presentation, either oral or written, on the subject of "The Importance of Science, Industry and Education to Community Progress."

The contest will be nationwide and local winners from all parts of the U. S. will be awarded trips to New Orleans to participate in the final judging. These will be the major awards.

- A $2000 scholarship to the winning student's choice of schools.
- A $2000 grant of unrestricted funds to the school to help defray the student's expenses.
- A $500 scholarship to the high-school teacher evincing the greatest interest, so the teacher may further his education.

The program will be backed by President Eisenhower who indicated he will endorse "Certificates of Participation." Several New Orleans banks have agreed to help with the student-participation fund program, and some 500 companies will contribute funds.

The section began setting up its program after the President created a special committee on scientific manpower to study the whole problem of the shortage of scientists, engineers and the related need for more students in these fields.

French Increase Refining Capacity

Capacity of French refineries increased by 68,000 barrels a day in 1955, reaching a daily capacity of 604,700 barrels. The increase was mainly due to a new refinery at La Mede, which has a daily output of 64,000 barrels.

Other notable gains were in the increase in domestic oil production, a cut in processing operations for foreign countries and a rise in direct exports.

Output of French refineries reached 22,950 tons of finished products in 1955, a 5 percent increase over 1954.

Use of Hydrogen Urged In Upgrading Heating Oil

Use of hydrogen in petroleum refining should have a "tremendously beneficial effect on heating-oil quality" in the next few years, a Shell Oil Company scientist told the API Division of Marketing.

The new development in heating-oil manufacture—previously impractical because of the high cost of hydrogen—was described by W. A. Sullivan, a member of Shell's Product Application department,

For more data on advertised products, use Readers' Service Cards, last page.

ALCOA ALUMINUM PIPE replaces corroded steel in world's first permanent aluminum underwater oil pipeline

Welded section of 4-inch ALCOA Aluminum Pipe being lowered into Lake Maracaibo, connecting underwater well of Creole Petroleum Corporation to flow station. After double jointing on shore, only six and one-half hours were needed to complete the job from the time welding operations began on the construction barge until the pipe was laid, nearly 20 feet below the lake surface.

Seven hundred feet of uncoated ALCOA Aluminum Pipe was recently submerged in Lake Maracaibo, Venezuela, as a pilot installation of the world's first permanent aluminum underwater oil pipeline. Corrosion-resistant ALCOA Aluminum replaced steel pipe carrying crude oil from an underwater well to a flow station in Creole's Bachaquero Field. Experience had shown that the steel pipe's protective coating was attacked by an aquatic borer, the Teredo, exposing the steel to corrosive action of the lake's brackish waters.

ALCOA's successful five-year operation of an undersea aluminum gas line in Matagorda Bay, Texas, demonstrated aluminum's suitability for this type of application. Moreover, exhaustive tests conducted by ALCOA's Aluminum Research Laboratories indicated that certain ALCOA Aluminum alloys have the necessary resistance to salt water and crude oil corrosion to last many years at this installation.

ALCOA Aluminum Pipe has other advantages as well. It is light in weight for quick assembly and portability. It costs less per foot than any other corrosion-resistant metal pipe, and its ease of installation adds to its economy. Its nonsparking characteristic insures the safe handling of inflammables. Some sizes are available in more than one thickness to meet varying service requirements.

Compare the advantages of ALCOA Aluminum with the pipe you are now using. Write today for the new, FREE booklet, *Alcoa Aluminum Pipe and Fittings*, which gives valuable technical data plus complete information on cutting, bending and joining. Use the coupon.

Aluminum Company of America
905-F Alcoa Building
Pittsburgh 19, Pennsylvania

Please send me your FREE booklet, *Alcoa Aluminum Pipe and Fittings.*

Name_____

Company_____

Address_____

City_____ Zone____ State_____

ALCOA ALUMINUM
ALUMINUM COMPANY OF AMERICA

For more data on advertised products, use Readers' Service Cards, last page.

in a paper before the division's mid-year meeting in Atlanta.

He pointed out that hydrogen, used in a process that "greatly increases the stability" of heating oils, is now available as a byproduct from catalytic reformers. Improvement of conventional refining techniques and more effective use of additives also will raise heating-oil quality, he said.

Playing down the fears of those who thought the advent of catalytic cracking would lead to deterioration of heating oil quality, Sullivan said that heating oils containing catalytically-cracked stocks have proved better than those made prewar from straight-run and thermally-cracked distillates.

Screen-clogging tests made at Shell's Sewaren, N. J., fuel oil research laboratory show that heating oil quality has improved about 50 per cent in the last five years. Sullivan predicted that further improvement will be aided by new, precise testing methods that will permit closer control of quality.

Demand for Oil Up; Refined Stocks Down

Total demand for all oils in the first quarter of 1956 averaged 9,750,000 barrels a day, according to an estimate by the Bureau of Mines. This is 5.6 percent more than the demand for the same period a year ago.

In its monthly forecast, the bureau saw domestic crude demand averaging 6,970,000 barrels a day in May, compared with 6,940,000 barrels forecast for April. The May forecast includes gasoline demand of 124 million barrels, a yield of 43.1 percent and total refinery runs of 7,750,000 barrels a day.

The bureau estimated refined stocks on March 31 at 408 million barrels, about 1 million less than a year ago. But California stocks accounted for more than all of the decrease—down 15 million barrels—as east of California stocks were up 14 million barrels.

Of the stock total, gasoline accounted for 200 million barrels, up about 16 million barrels.

Of the stock total, gasoline accounted for 200 million barrels, up about 16 million from a year ago. But the bureau noted that April refinery runs had been cut sharply to reduce stocks to a more normal seasonal level.

Statistics Recommended For Road-Test Programs

Proper planning of road-test programs can reduce the cost of evaluating the road antiknock quality of gasoline blends, Eric Sorensen of The British American Oil Company, Ltd., told an API Division of Refining meeting in Montreal.

Presenting a paper coauthored with F. D. Buerstetta and W. C. Healy, both of Ethyl Corporation, and W. J. McGuire of British American, Sorensen noted that the rising antiknock requirements of engines impel refiners to study the road behavior of blending stocks. He pointed out, however, that the cost required for an extensive program of road testing may be prohibitive for the smaller refiner.

But the application of statistical methods to the choice of test blends from the possible blending combinations permits a reduction in the number of blends required for a sound analysis, Sorensen said. Thus, for a small refiner operating within a moderate research budget, statistical techniques permit road-test studies which might otherwise be too expensive. The chief attraction of a statistically-planned approach is that it results in greater research efficiency.

Road test results of blends at the 94-octane-number level were outlined by Sorensen. The data analysis showed that, for blends of five representative refinery stocks, best road performance could be secured by making the ratio of the catalytic reformate to the catalytic-cracked component a maximum. If catalytic reformate is not available, replacement of catalytic-cracked stock with straight-run and thermal-cracked stocks is beneficial to some extent, he pointed out.

Four Companies Take Public Interest Awards

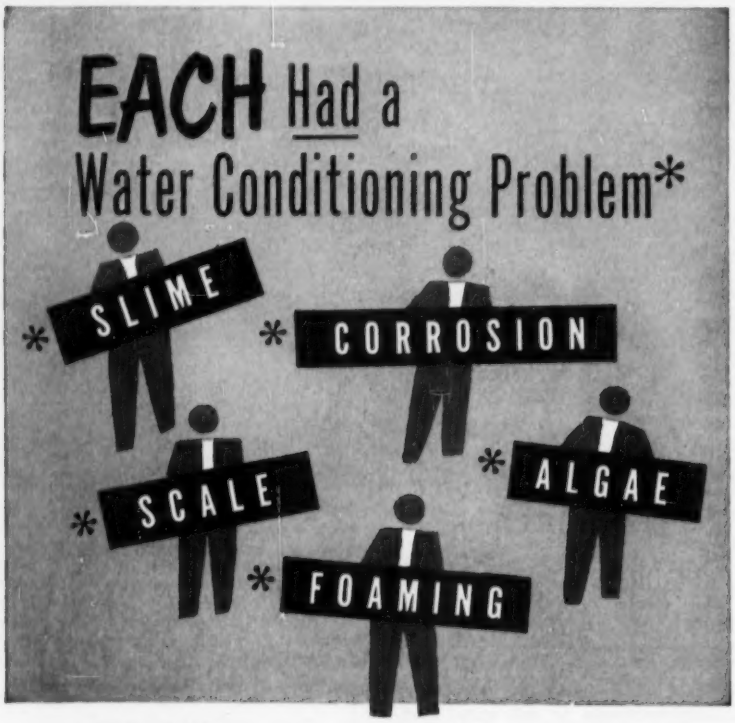
Six petroleum companies were among the recipients of the National Safety Council's 1955 Public Interest Award.

The advertising campaigns of the six companies—American Oil Company, Esso Standard Oil Company, Ethyl Corp., Humble Oil & Refining Company, Imperial Oil, Ltd., and Standard Oil Co. (Indiana)—were cited by the council for exceptional service to safety in 1955.

The companies contributed time and space in many advertising media for the promotion of accident prevention.

Boards Approve Merger

The proposed acquisition of Cosden Petroleum Corporation by W. R. Grace & Company has been approved by the directors of both companies. It will have to be



EACH Found the Answer at Wright!

Wright never offers a "cure-all" . . . your water conditioning problems are individually studied and analyzed by our technical staff. The answer to each problem is contained in a complete personalized report prepared especially for you. After you adopt our recommendations, constant field and laboratory checks insure proper, economical performance. Write or call collect today for a complete survey of your individual water conditioning problems.

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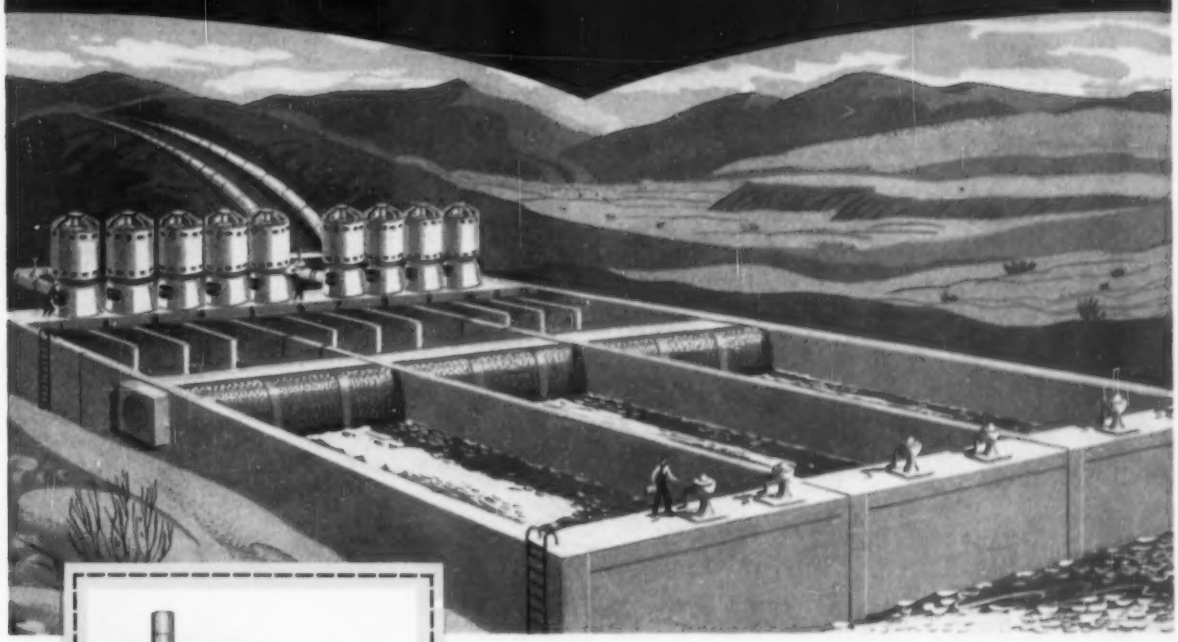
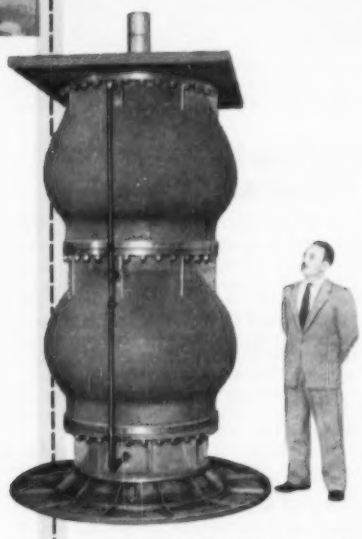
GENERAL OFFICES AND LABORATORY • 615 WEST LAKE STREET, CHICAGO 6, ILLINOIS

Offices in Principal Cities

- Softeners, Filters and Other External Treating Equipment
- Nelson Chemical Proportioning Pumps

Giant new Tidewater refinery selects Byron Jackson pumps for 400 MGD service





TWO STAGE BJ PUMP shown without discharge head and motor.

SPECIAL ENGINEERING REPORT AVAILABLE:

A special engineering report with detailed flow diagrams and color photographs is available. Also, a factual full-color motion picture report can be arranged on request.

Tidewater Oil Company's new Delaware Flying A Refinery is one of the world's largest new refineries. This giant refinery—15 miles south of Wilmington—will use more than 16 million gallons of water per hour. To accomplish this mammoth pumping job, Tidewater and C. F. Braun & Co. (engineers and constructors) selected nine BJ 2000 hp vertical river intake pumps, with provision for installation of three more units.

BJ Pre-Tested the Actual Installation

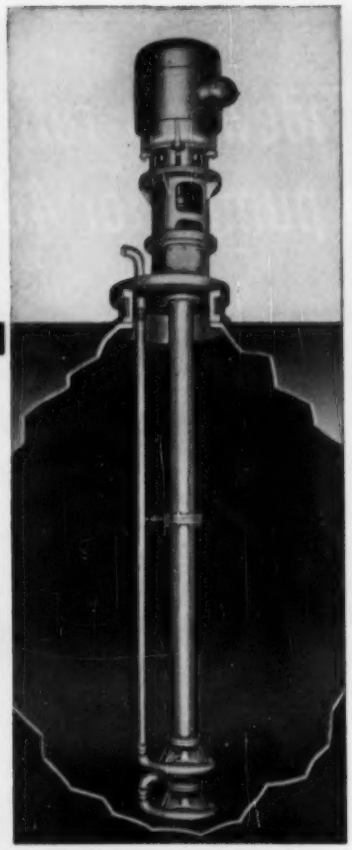
Because of the special intake system and the untested hydraulic problems involved, it was decided to pre-test the actual pumping conditions. A scale model intake installation—including nine pumps—was constructed in Byron Jackson's Los Angeles hydraulic laboratory. Actual field operations were duplicated in this model. All tests confirmed the correctness of engineering and pumping specifications. In addition, before delivery, Byron Jackson performed exacting hydraulic tests on each of the nine pumps. *These giant pumps tested to an 89.5% efficiency!*

Each BJ pump will be driven by a 2000 hp electric motor at 600 rpm against a total head of 184 feet. Because of the brackish salt water, pump cases, columns and impellers are made of high alloy stainless steel.

BJ
SINCE 1872

Byron Jackson Pumps, Inc.
A Subsidiary of Borg-Warner Corp.
P.O. BOX 2017A, TERMINAL ANNEX • LOS ANGELES 54, CALIFORNIA

For more data on advertised products, use Readers' Service Cards, last page.



Lawrence 2-Stage Vertical Pump for Pumping Liquid Chlorine out of Tanks.

PUMPS to handle LIQUID CHLORINE

Pumping liquid chlorine calls for more ingenuity and engineering skill than is available from the average pump manufacturer. Formerly it was pumped pneumatically. This method was attended by a considerable loss of chlorine because the moisture in the air formed hydrochloric acid. A further complication was the corrosive action of the acid vapors.

To overcome this, Lawrence engineers in collaboration with manufacturers of chlorine, developed a pump with a special packing box which prevents any contamination of the chlorine or corrosion of any of the equipment and also prevents the escape of the chlorine fumes to the atmosphere.

For over 80 years Lawrence has been making pumps to handle every acid or chemical fluid used in industry. If you have a particularly difficult chemical pumping problem, we can save you both time and money. Write us the pertinent details, no obligation.

Send for Bulletin 203-7 for a complete summary of acid and chemical pump data.

LAWRENCE PUMPS

LAWRENCE PUMPS INC.

371 MARKET STREET, LAWRENCE, MASS

What's Happening . . .

submitted to stockholders of both companies for final action.

The merger would give Grace a sound position in the petroleum industry, fitting into its expanding petrochemical activities.

NGAA Asks API To Handle LPG Statistics

Preliminary plans for the collection and compilation of more current statistics on the production and stocks of LP gas are being considered by American Petroleum Institute.

The gathering of this information will be undertaken at the request of the Natural Gasoline Association of America.

In making its request, NGAA noted that the natural-gasoline industry would prefer that API handle the project because of the institute's experience in such activities and because of the high acceptance of its statistical reports.

Plans call for reports to be published semimonthly, about the first and fifteenth of each month.

In compiling its statistics, the institute will use the same definitions currently used by the Bureau of Mines. Eight geographical districts will be involved, based on portions and combinations of Bureau of Mines refining districts.

The data will indicate production and inventories of propane, butane, butane-propane mix, iso-butane and other mixtures. For production figures of some products, however, it will be necessary to gather basic figures on shipments, relating these through inventories back to production.

All companies now reporting LP gas shipments and stocks to the Bureau of Mines on a monthly basis, will be asked to join in the effort—including companies operating LPG plants, companies producing PLG at refineries and companies operating terminals and other storage facilities.

Kellogg to Help Train Petrobras Personnel

The M. W. Kellogg Company, with a contract to handle engineering for a major expansion of the Petroleo Brasiliero refinery at Mataripe (**see Who's Building**), also has been selected to undertake a training program for the refinery's operating staff.

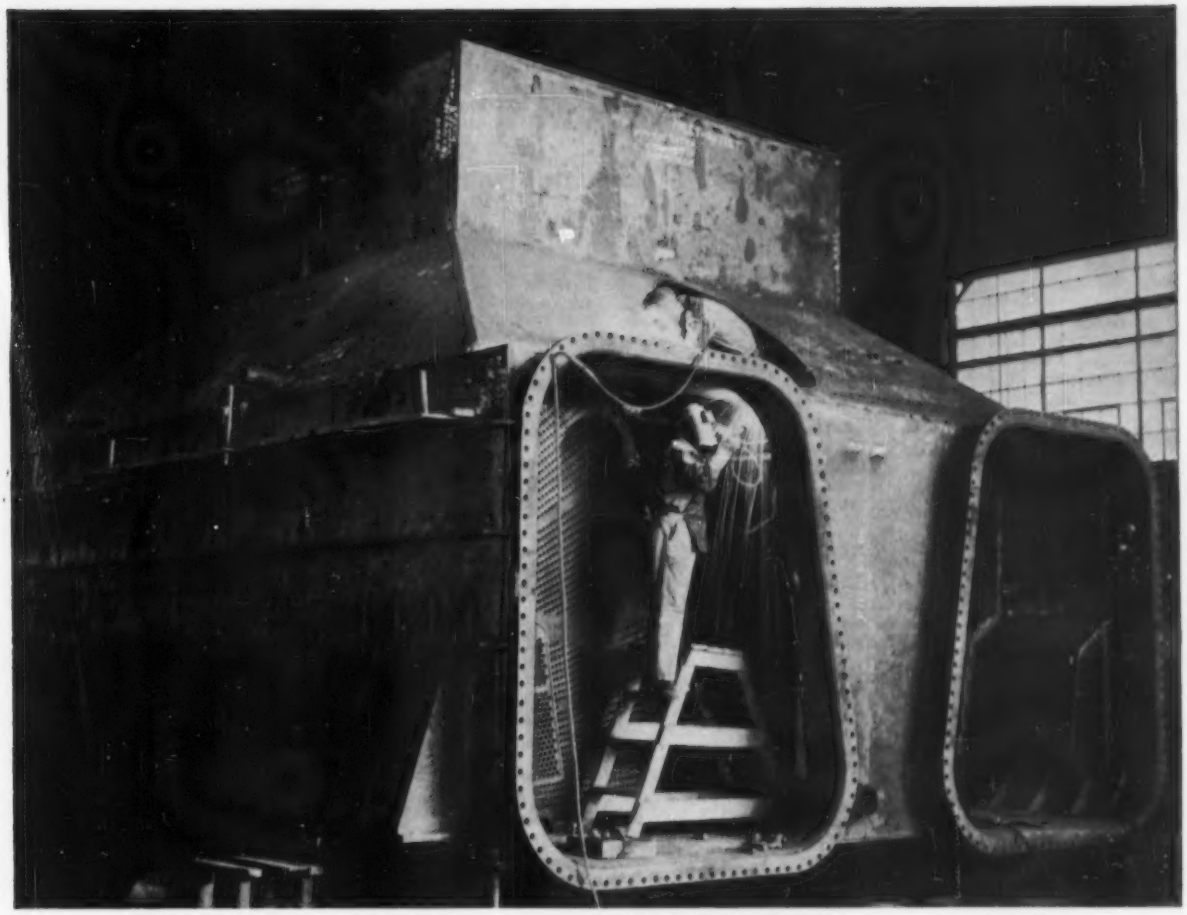
As part of the over-all training program, Kellogg will bring Petrobras refining personnel to the U. S. to study techniques and operations in refineries and vendor shops here. The group will be in this country about a year an a half.

In addition to training personnel for the expanded Mataripe refinery, Kellogg will help develop an organization for the Brazilian oil agency to use in its own petroleum-refinery training program.

FMC Research Project Underway on NYU Campus

A new kind of university-industry cooperation for research is underway between New York University's College of Engineering and the Chemical divisions of Food Machinery & Chemical Corporation.

Last fall, the college's Research division and FMC established an advance research laboratory on the university's Bronx campus. When FMC completes construction of



this surface condenser was specially designed to save space

Pictured above in the final stages of construction is a surface condenser designed by Lummus to save much-needed space at the White River Station of the Indianapolis Power & Light Company. The rectangular shape permits low headroom installation. Bayonetting a low pressure stage heater in the dome saves even more space.

This condenser, about to be placed in operation as unit #6 at the White River Station, has a total of 50,000 sq. ft. of tube surface, and was furnished complete with circulating water and condensate pumps and drivers, and a Lummus-designed air ejector unit.

Lummus was highly commended by Gibbs and Hill Inc.—the consulting engineers—and by the customer for efficient handling of engineering details, and for the workmanship which went into the building of the condenser in the Lummus plant. Lummus has been retained to build a second, duplicate unit at Indianapolis' Harding Street Station.

By working closely with consultants and the customer, Lummus engineers were able to solve a knotty space problem frequently encountered in power station design. These same men would be pleased to work with you on similar problems. Call on them.

THE LUMMUS COMPANY, 385 Madison Avenue, New York 17, New York. *Engineering and Sales Offices:* New York, Houston, Montreal, London, Paris, The Hague, Bombay. *Sales Offices:* Chicago, Caracas. *Heat Exchanger Plant:* Honesdale, Pa. *Fabricated Piping Plant:* East Chicago, Ind.

LUMMUS

THE LUMMUS COMPANY, HEAT EXCHANGER DIVISION • 385 MADISON AVENUE, NEW YORK 17, N. Y.

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What's Happening . . .

its chemical research laboratories in Princeton, N. J., this summer, the unit at NYU, together with its personnel, will move there.

Meanwhile under the FMC-NYU contract, a five-man research team has access to the Engineering Research division's facilities and to the consultation services of faculty and staff members. In addition, a NYU graduate student assisting in the research has received a $3000 FMC fellowship for study toward advanced degrees in chemical engineering.

Research in the project includes exploratory petrochemical investigations in polymerization, alkylation reactions and resin formation, and general preparation and evaluation of catalysts for hydrocarbon reactions.

Major units in the laboratory are distillation columns, Orsat gas apparatus, a gas chromatograph, an ultra-violet spectrophotometer, an infra-red spectrophotometer and a vapor-phase catalytic reactor unit.

Change Tidewater Name

Stockholders of Tide Water Associated Oil Company have approved a proposal to shorten the firm name to Tidewater Oil Company.

This action was taken at a meeting at which the company was reported as earning a net profit of $9,037,000 for the first three months of 1956. This is compared with its net earnings of $8,083,000 in the first quarter of 1955.

PROOF POSITIVE

foster MASTIC COATING RESISTS FIRE

Arc welding above freshly-applied Foster 60-60N (left) fails to ignite coating; while ordinary asphalt mastic (right) ignites and burns fiercely until consumed.

foster Fire-Resistive Mastic 60-60N is:

Non-flammable during (and after) application by spray or trowel—no danger of ignition from welding sparks or splatter.

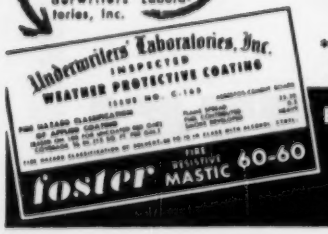
Fire-resistive when dry, won't add fuel to accidental fire exposure. (Foster 60-60 is still the only weather-coating listed by Underwriters' Laboratories).*

An effective barrier to moisture vapor; a requirement for coating low temperature thermal insulations, (vapor permeance 0.02 perm).

Outstanding for protecting steel and thermal insulation from weather and chemicals (both liquid spillage and atmospheric fumes);

Unparalleled by any conventional mastic coating for retained flexibility under prolonged heat and sunlight.

A companion product, Foster's Fire-Resistive Mastic 60-60 is listed and inspected by the Underwriters' Laboratories, Inc.

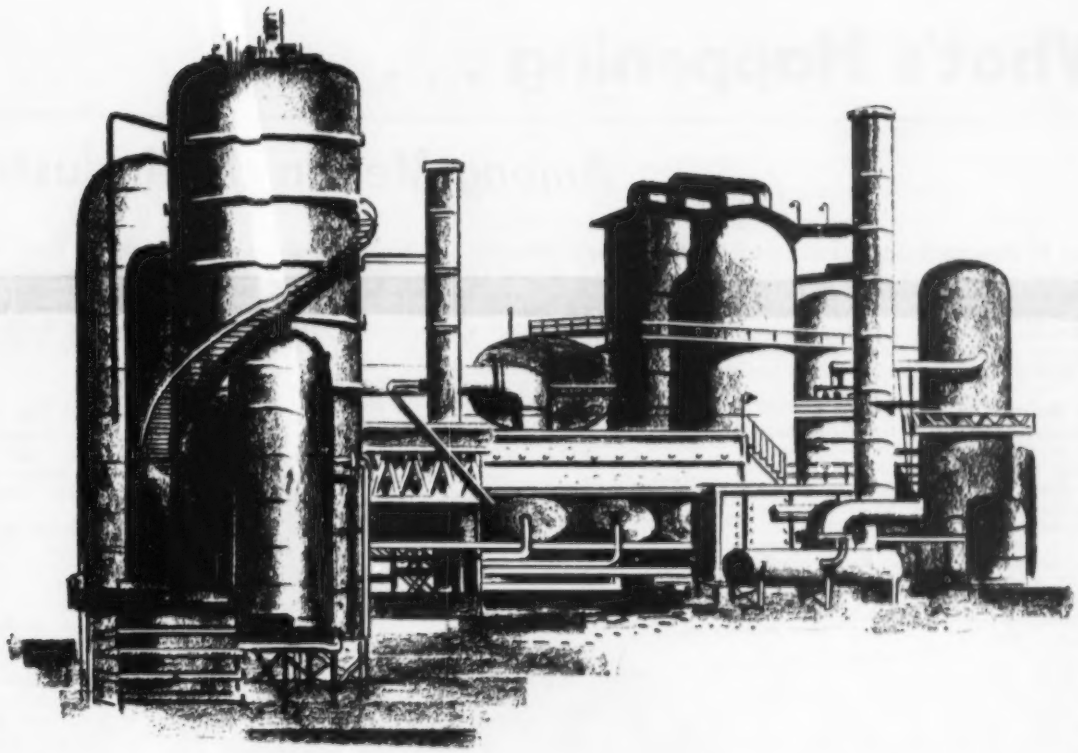


*Dry film of 60-60N is identical with dry film of 60-60. 60-60N is an improved mastic made with non-flammable, non-toxic volatile solvent.

BENJAMIN foster COMPANY
4635-37 W. Girard Avenue
PHILADELPHIA 31, PA.
Distribution and Technical Services available in principal U. S. and Canadian Industrial Areas.

MEETINGS CALENDAR

JUNE	
11–15	Technical Conference on Plastics, Sponsored by The Society of the Plastics Industry, Inc., Coliseum, New York.
17–21	American Society of Mechanical Engineers, Semi-Annual Meeting, Hotel Statler, Cleveland.
17–22	World Power Conference, Vienna, Austria.
17–22	American Society for Testing Materials (Annual Meeting and Apparatus Exhibit), Chalfonte-Haddon Hall, Atlantic City, N.J.
17–23	International Congress on Acoustics, Sponsored by Harvard University and Massachusetts Institute of Technology, Cambridge, Mass.
18–20	American Society of Heating and Air-Conditioning Engineers, Shoreham Hotel, Washington, D.C.
21–22	Western Petroleum Refiners Association, Regional Technical-Industrial Relations Meeting, Broadview Hotel, Wichita, Kans.
24–25	Canadian Gas Association, Manoir Richelieu, Murray Bay, Quebec.
25–29	American Institute of Electrical Engineers (Summer and Pacific General Meeting), San Francisco.
28–30	Rocky Mountain Oil and Gas Association, Mid-year Meeting, Utah Hotel, Salt Lake City.
JULY	
17–27	Massachusetts Institute of Technology, Special Summer Program on Recent Advances in Catalytic Polymerization, Cambridge, Mass.
18–21	Silver Bay Conference on Human Relations in Industry, Silver Bay, New York.
AUG.	
9–11	Denver Research Institute, Annual Symposium on Industrial Applications of X-Ray Analysis, Albany Hotel, Denver, Colorado.
SEPT.	
9–12	American Institute of Chemical Engineers, William Penn Hotel, Pittsburgh.
10–12	American Society of Mechanical Engineers, Fall Meeting, Cosmopolitan Hotel, Denver.
10–14	International Congress on Catalysis, Bellevue-Stratford Hotel, Philadelphia.
12–14	National Petroleum Association, Annual Meeting, Traymore Hotel, Atlantic City.
16–21	American Chemical Society, Annual Meeting, Atlantic City.
17–19	American Institute of Electrical Engineers, Annual Electrical Conference of the Petroleum Industry, Kansas City, Mo.
17–21	American Society of Mechanical Engineers, Instruments and Regulators Division and Instrument Society of America Exhibit and Joint Conference, Coliseum, New Work.
17–21	Annual Instrument-Automation Conference and Exhibit, Sponsored by the Instrument Society of America, Coliseum, New York.
20–21	Mid-Continent Oil and Gas Association, Louisiana-Arkansas Division Roosevelt Hotel, New Orleans.
20–21	Mid-Continent Oil & Gas Association, Louisiana-Arkansas Meeting, Hotel Roosevelt, New Orleans
20–21	Western Petroleum Refiners Association, Technical Industrial Relations Meeting, Henning Hotel, Casper, Wyo.
16–22	American Society for Testing Materials, National Meeting and Apparatus Exhibit, Hotel Statler, Los Angeles.
23–26	American Society of Mechanical Engineers, Petroleum Mechanical-Engineering Conference, Conrad Hilton Hotel, Dallas.
24–28	Trade Fair of the Atomic Industry, Sponsored by the Atomic Industrial Forum, Navy Pier, Chicago.
OCT.	
8–10	American Society of Mechanical Engineers—American Society of Lubrication Engineers, Third Lubrication Conference, Chalfonte-Haddon Hall, Atlantic City, N.J.
24–25	American Society of Mechanical Engineers—American Institute of Mining and Metallurgical Engineers, Joint Fuels Conference, Sheraton-Park Hotel, Washington, D.C.

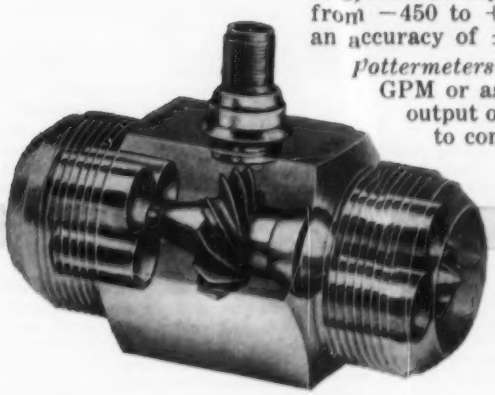


FOR VITAL FLOW CONTROL

WHETHER you're developing a new process or modernizing an old one—investigate the unique characteristics of the bearingless *Pottermeter*.

This electronic flowmeter—easily installed in any type of piping to operate at any angle, at any pressure and at temperatures from −450 to +1200°F, measures flow of any liquid with an accuracy of ±½ of 1%.

Pottermeters are available to measure flows as low as 0.07 GPM or as high as 3,000 GPM. The inherently linear output of the *Pottermeter* makes it ideal for systems to control either flow rate or total flow.



Find out how the bearingless "floating rotor" used in the *Pottermeter* can give you more precise flow measurement, longer trouble-free service life, and more accurate flow control.

Write for Bulletin PS-1

Potter

POTTER AERONAUTICAL COMPANY

Route 22 • Union, New Jersey • Phone MUrdock 6-3010

Makers of "Potter Engineered" products

For more data on advertised products, use Readers' Service Cards, last page.

What's Happening . . .

. . . *Among Men* in the Industry

James R. Duncan has been appointed comptroller and treasurer of The M. W. Kellogg Company. He succeeds **D. J. Olsen**, who retired after 44 years with the company. Duncan was assistant to the comptroller of United Merchants and Manufacturers.

P. H. Bohart, a vice president of Gulf Oil Corporation, has been transferred from Tulsa to Pittsburgh as head of a new Planning and Economics department set up to obtain information, studies and recommendations concerning the company, the oil industry and business in general.

Bohart, who also will serve as chairman of the company's Economics Review council, will report directly to the president and executive vice president in connection with company-wide responsibilities for planning studies.

With Gulf since 1919, Bohart has spent most of his time in production. In 1945, he served with the Petroleum Administration of War, and in 1947, he made a special survey of operations of the Gulf-affiliated Kuwait Oil Company, Ltd. He became a vice president in 1950.

J. Russell Wilson, a vice president of Monsanto Chemical Company, has been named general manager of a recently-created Domestic Subsidiaries and Affiliates division.

The new division was set up to administer Monsanto's interest in Shawinigan Resins Corporation, Springfield, Mass.; The Chemstrand Corporation, Decatur, Ala.; Mobay Chemical Company, St. Louis, and other companies in which Monsanto has an affiliation.

Named to succeed Wilson as general manager of the Research and Engineering division was **Howard K. Nason**, formerly director of research and development in the Organic Chemicals division. Wilson had been manager of the Research and Engineering division since early 1956.

N. N. T. Samaras, assistant general manager of the Research and Engineering division, has been given a special assignment with the company's Executive Committee.

At the same time, Wilson was appointed director of the Patent department.

E. L. Hildebrand has been promoted to engineering specialist in the Engineering division at the Humble Oil & Refining Company refinery at Baytown, Texas. Also advanced in that division were **R. F. Worth**, named supervising engineer, and **W. L. Martin**, who was promoted to senior mechanical engineer.

In the Research and Development division, **R. C. Halter** and **J. F. Mathis** were advanced to research specialists, and **Margie M. Nicholson** and **F. W. Lampe** were promoted to research chemists.

The Mechanical and Construction division promoted **Ben S. Love** to head the Materials group. **B. L. Ward** was advanced to general foreman and **R. R. Bains** to assistant general foreman of the Labor and Brickmason department.

W. B. Strobel, director of projects development in Continental Oil Company's Petrochemical department, has been selected from U. S. industry to receive a 1956-57 Sloan Fellowship at Massachusetts Institute of Technology.

Strobel is the fifth Conoco man in seven years to receive a Sloan Fellowship. Previous winners are **Oswald Newell, Jr.**, and **James W. Bateman**, both members of Conoco's Manufacturing department in Houston; **Loren D. Grubb**, assistant superintendent at the company's Ponca City refinery, and **William F. Brown**, superintendent of the Conoco refinery at Lake Charles.

Established by Alfred P. Sloan Foundations, Inc., the Sloan Fellowship Program for Executive Development was founded

STROBEL

in 1938 to train promising young technical executives in the broader phases of industrial management and to prepare them for future positions of business leadership. The course extends from June, 1956, to June, 1957.

Strobel, with a master's degree in chemical engineering, joined Continental Oil Company at Ponca City in 1938, following graduation from the University of Colorado. He served in technical positions in the Manufacturing department at Ponca City three years before he was transferred to Houston in 1951 as technical assistant to the manager of the Petrochemical department. He was promoted to director of project development for the department there in 1954.

George F. Getty, II, has been appointed vice president and general manager of the Eastern division of Tidewater Oil Company. Until recently, Getty was executive vice president and director of Pacific Western Oil Corporation and director of Spartan Aircraft Company.

Charles H. Brown has been made superintendent of the Power department at The Atlantic Refining Company's refinery in Philadelphia. He succeeds **W. A. Schmidheiser** who is retiring. Brown was assistant superintendent of the Power department.

J. C. D. Oosterhout, with The Texas Company at its Port Arthur refinery, is part of the first father-and-son team to be graduated from Beaumont's Lamar State College of Technology. His son, Kenneth, is the team's other half.

The elder Oosterhout, a senior chemist in Texaco's Research division, will receive a bachelor of science degree in chemistry, and his son will take a B. S. degree in chemical engineering.

The son will start graduate studies in September at the University of Illinois, where he has been offered a $1500 scholarship in the Department of Chemistry and Chemical Engineering. He will teach and supervise some of the department's laboratories while working for his advanced degree.

The elder Oosterhout completed work started in his native Amsterdam, Holland. Before coming to the U. S. in 1921, he finished what is the equivalent of junior college work.

Oosterhout joined The Texas Company at Port Arthur in 1921 in the refining and research laboratories. All his college work has been done at Lamar Tech College in the night session since September 1951.

Robert S. Ray and **Jack Tielrooy** are new vice presidents of Brea Chemicals, Inc. Ray is the company's manager of manufacturing, and Tielrooy is its development manager.

The company, a subsidiary of Union Oil Company of California, also has named **Paul Foreman** as secretary and treasurer. He was secretary and manager of staff.

W. W. Phillips, formerly assistant comptroller, was promoted to comptroller; **Jay Linderman**, who was assistant secretary, was made assistant secretary and assistant treasurer, and **William C. Van Siclen** was elected assistant comptroller and assistant treasurer.

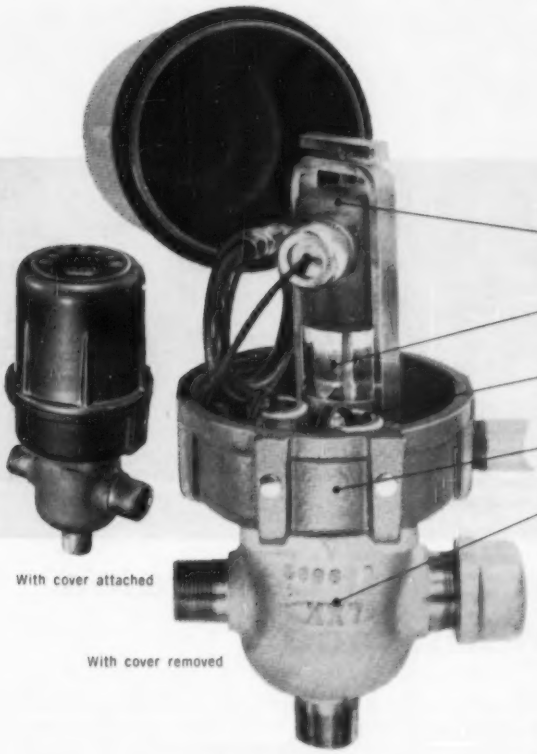
Richard M. Wood has been appointed construction manager for Stone & Webster Engineering Corporation, with headquarters in the company's Boston office. With the company since 1921, Wood had been assistant construction manager at Boston since 1947. He received his civil-engineering degree at Johns Hopkins University in 1922.

John E. Powers, assistant professor of chemical engineering at the University of Oklahoma, has been awarded a National Science Foundation grant in the amount of $11,500.

Dr. Powers will use the grant to conduct theoretical and experimental research on the influence of barrier systems in

pH UNDER PRESSURE

The Beckman pH Flow Assembly is equipped with a *pressurized electrode* which allows you to get accurate pH measurements in process streams under pressure. A small pressure differential is maintained on the specially-developed reference electrode to prevent the process solution from contaminating the electrode and to keep the KCl liquid in the electrode flowing freely at the correct rate. Beckman Flow Assemblies are in use where solutions are moved about under pressure (chemical, petroleum), where sterilization is necessary (food, pharmaceutical), in large tanks and vessels where hydrostatic head or a variable liquid level is a problem. To learn how pH control may be applied to your process, mail the coupon today. Beckman Instruments, Inc., Process Instruments Department, Fullerton, Calif.

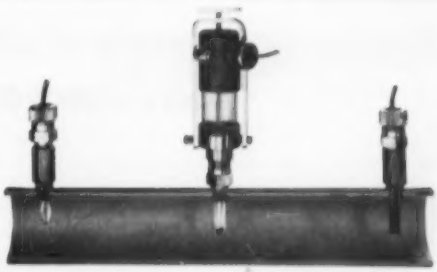


With cover attached

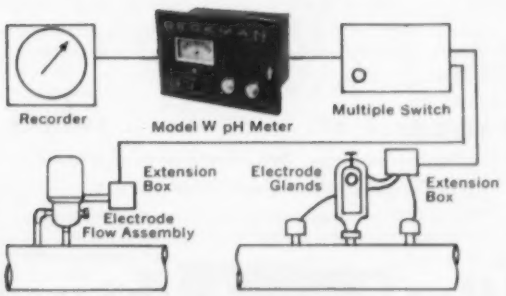
With cover removed

The Beckman Flow Assembly consists of these 5 elements:

1. **PRESSURIZED REFERENCE ELECTRODE** operates efficiently in pressures up to 100 psi. The electrode's large reservoir holds plenty of KCl and amount of liquid can be visibly checked at all times.
2. **BECKMAN GLASS ELECTRODE** is dependable, accurate and virtually unbreakable.
3. **THERMO-COMPENSATOR** is a resistance element that makes a true pH reading possible regardless of temperature changes (range from 32° to 212° F).
4. **CAST ALUMINUM BODY** prevents damage to electrodes. The leak-proof cover protects the unit from moisture and permits installations indoors or out.
5. **STAINLESS STEEL FLOW CHAMBER** resists corrosion from elements in the process stream.



THE GLAND ASSEMBLIES consist of the same elements (electrodes and thermo-compensator) and may be installed in a main process line with pressures up to 100 psi.



TYPICAL PRESSURIZED HOOK-UP. The *Flow Assembly* is installed into a sample or by-pass line, the *Gland Assemblies* directly into the main process line when a by-pass line is not practical. The *Multiple Switch* provides a means of monitoring up to six separate electrode assemblies with a single *Model W pH Meter*. A *Recorder-Controller* will automatically control the process to keep streams at a constant pH factor.

Beckman / *process instruments*
BECKMAN INSTRUMENTS, INC. FULLERTON, CALIF.

☐ Please send me a pH System Analysis Form that will entitle me to a free engineering analysis and recommendation for solving pH problems at our plant.

☐ Please send me a copy of "Industrial pH Measurement and Control" and add my name to your mailing list to receive additional information on pH control.

Name: _____ *Title:* _____

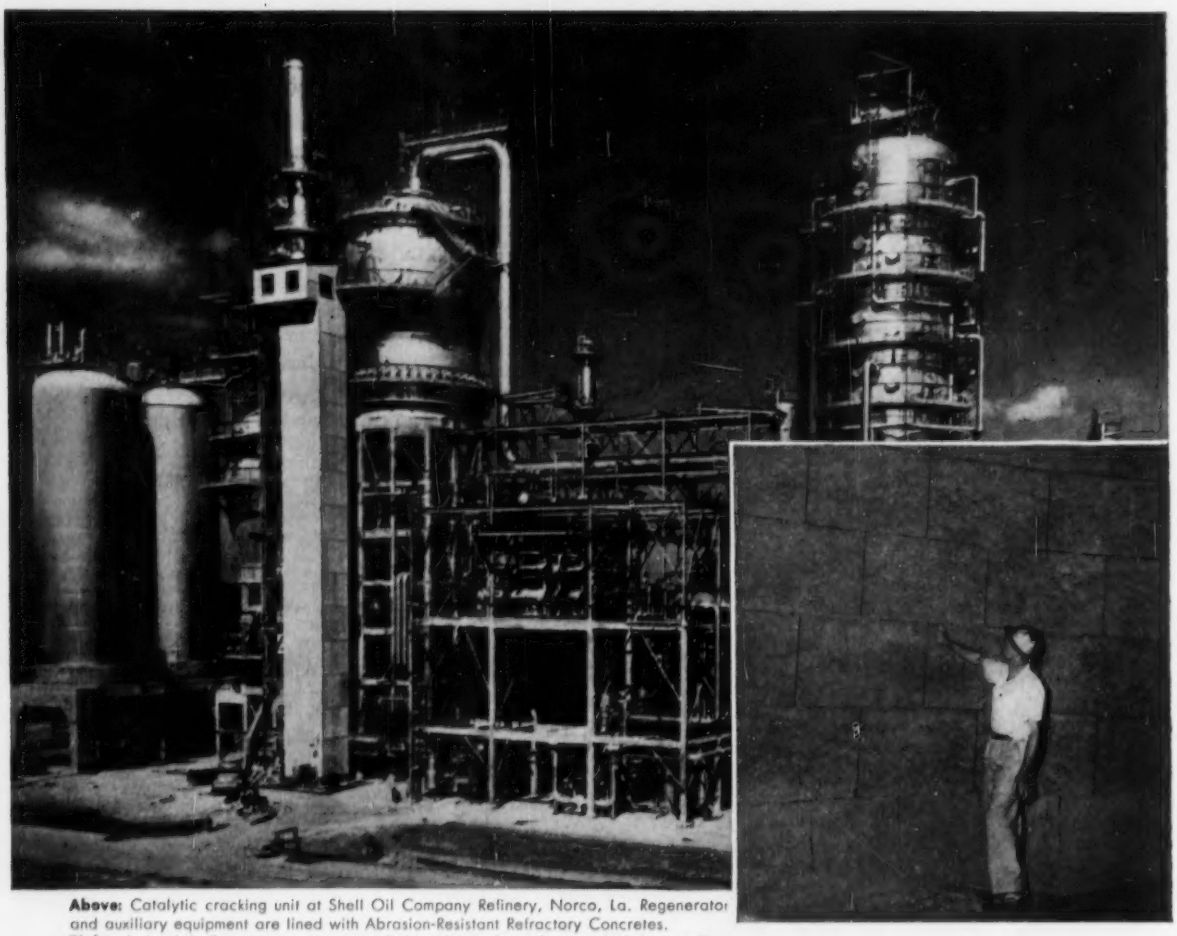
Firm: _____

Street: _____

City: _____ *Zone* _____ *State* _____

N10-25

For more data on advertised products, use Readers' Service Cards, last page.



Above: Catalytic cracking unit at Shell Oil Company Refinery, Norco, La. Regenerator and auxiliary equipment are lined with Abrasion-Resistant Refractory Concretes.
Right: Industrial Concrete regenerator lining shown here is reported in excellent condition after a year of service.

How refineries use Industrial Concretes for better performance

The cat-cracking unit above used Industrial Concretes made with Lumnite* cement to line and insulate the regenerator, insulate the stack, line the reactor cone and most of the risers and standpipes. The performance of Lumnite concretes in this and many similar installations has proved its effectiveness. Why not consider how many time- and money-saving uses your plant can make of Lumnite concretes?

Here are some of the typical ways refineries are using Lumnite concretes: *Refractory* linings for heaters and installations with high service temperatures; *Refractory-Insulating* linings where both properties are needed; *Corrosion-Resistant* linings for equipment, tanks and trenches subject to acid attack; *Abrasion-Resistant* linings where moderate wear reduces service life.

For added convenience in placing Industrial Concretes, castable refractories were used on this job. Castables are packaged mixes containing Lumnite calcium-aluminate cement and a variety of selected aggregates to provide concretes that meet a variety of temperature and insulating needs. All you do is add water, mix and place. Castables are made and distributed by leading manufacturers of refractories. To line the above regenerator, 3″ of SK-7 castable was applied for insulation, and then 1″ of KS-4 was applied in hex-steel. Both these castables are made by A. P. Green Firebrick Co., Mexico, Mo. For further information contact:

UNIVERSAL ATLAS CEMENT COMPANY
UNITED STATES STEEL CORPORATION SUBSIDIARY
100 PARK AVENUE, NEW YORK 17, N. Y.

*"LUMNITE" is the registered trademark of the calcium-aluminate cement manufactured by Universal Atlas Cement Company

PR L-127

Atlas® Lumnite Cement
FOR INDUSTRIAL CONCRETES
REFRACTORY • INSULATING • OVERNIGHT • CORROSION-RESISTANT

OFFICES: *Albany · Birmingham · Boston · Chicago · Dayton · Kansas City · Milwaukee · Minneapolis · New York · Philadelphia · Pittsburgh · St. Louis · Waco*

United States Steel Hour – Televised on alternate Wednesdays – See your local newspaper for time and station.

Men in the Industry . . .

thermal-diffusion processes which separate components of liquid mixture.

Before joining the university faculty, Dr. Powers was with Shell Development Company at Emeryville, Calif. He completed his Ph.D. at the University of California in 1954.

M. P. L. Love has been named manufacturing vice president of Shell Oil Company succeeding **F. S. Clulow** who will retire after nearly 36 years with the company.

Love

Love joined Shell in 1935 as a junior chemist at the Wood River, Ill., refinery. Two years later he became a senior research chemist. After positions of increasing responsibility at Wood River, in the New York office and in the Houston research laboratory, he became manager of the Manufacturing Research department in New York in 1948.

In 1951, he became manager of the Houston refinery, where he remained until 1954. Recently, he has been on a special assignment.

Clulow was named a department manager at the Martinez, Calif., refinery in 1930, following ten years of service with the Shell organization.

In 1934 he became manager of the East Chicago, Ind., refinery, and in 1938 returned to the West Coast to become manufacturing vice president with headquarters in San Francisco. In 1949, after the consolidation of the Pacific Coast and East of the Rockies manufacturing organizations, he was moved to New York as manufacturing vice president for all Shell refineries.

Guy W. Duren, superintendent of the Cities Service-operated West Seminole, Texas, gasoline plant, is being transferred to Bartlesville to serve as senior process engineer in Cities Service Oil Company's Natural Gasoline division. **Edgar B. Lord,** maintenance superintendent at the West Seminole Plant, is being advanced to plant superintendent.

Duren joined Cities Service as a member of its engineer training program in 1948. He served in various capacities in the company's Natural Gasoline division. He was transferred to the new West Seminole plant in 1954 as superintendent.

Lord joined Cities Service in 1926 and has worked in many of the company's natural gasoline and chemical plants. Before his appointment as maintenance superintendent at West Seminole, he was stationed at one of the company's Oklahoma City plants.

Vernon R. Dodd recently joined the West Seminole plant staff and will serve as maintenance superintendent. Dodd joined Cities Service in 1927 and has served for the past eight years as maintenance superintendent at the Tallant plant.

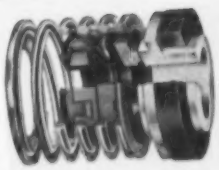
Allen R. Kittleson has been selected by the board of directors of Esso Research and Engineering Company for one of the company's highest-ranking titles.

He was named a senior research associate. Only three other employes hold this

3 JOHN CRANE Shaft SEALS for lifetime performance in any petroleum or petrochemical service

TYPES 1 and 2

Synthetic Rubber Bellows • For Low Pressure Service



Services: gasoline, diesel fuel, fuel oil, crude oil, butane, propane, ethane and similar products non-injurious to synthetic rubber.

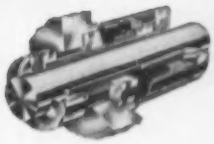
Pressures: to 200 psi.

Temperatures: —40°F to +212°F.

Construction Data: Factory assembled. Self-adjusting sealing head. Lapped faces positively prevent leakage. Low spring pressure for minimum wear. *Available in balanced construction for pressures to 550 psi.*

TYPE 8B

Packaged Type Seal • For High Pressure Service



Services: Same as Types 1 and 2.

Pressures: to 1200 psi.

Temperatures: —40°F to +250°F.

Construction Data: Heavy duty. Hydraulically balanced to handle high pressures. Single-unit package for easy installation.

TYPE 9

Sealing Members Made of Teflon* • Engineered for service conditions that do not permit use of rubber

Services: alkyl benzine, benzine, creosote, silicone oil, some petroleum derivatives, and all known corrosives.

Pressures: to 150 psi. (balanced construction to 750 psi.)

Temperatures: —120°F. to +500°F.

Construction Data: Furnished in the metallurgical specification best suited to the particular service. Flexible wedge ring and sealing ring molded from chemically inert Teflon.

Contact "John Crane" for the shaft seal best suited to your requirements. Request bulletin giving full information on "John Crane's" complete line of mechanical seals.

Crane Packing Co., 6420 Oakton St., Morton Grove, Ill., (Chicago Suburb). *In Canada: Crane Packing Co., Ltd., Hamilton, Ont.*

*DuPont trademark

JOHN CRANE CRANE PACKING COMPANY 38 YEARS INDUSTRIAL PROGRESS

For more data on advertised products, use Readers' Service Cards, last page.

Men in the Industry...

distinction in the scientific affiliate of Standard Oil Company (New Jersey).

Kittleson, who joined Esso Research in 1937, is the inventor of a highly-effective fungicide. Scientists at Rutgers University, where the discovery was tested, described it as "one of the significant steps" in agricultural chemicals.

Before World War II, his experiments dealt with petrochemical processes and resulted in several improvements in lubricant additives.

Paul E. Hall has been promoted to vice president in charge of sales and development for Wyatt C. Hedrick Engineering Corporation. Others promoted to vice president in the Houston concern were **David N. McClanahan,** who will be in charge of process and chemical engineering, and **Edwin D. Redding,** given charge of project and design engineering.

William P. Hourihan has been elected treasurer of Esso Research and Engineering Company, and **Ray F. Obrock** has been named comptroller.

The company recently created a Treasurer's division and a Comptroller's division, replacing a General Business and Accounting office. Hourihan also is director of the Treasurer's division, while Obrock heads the Comptroller's division.

Douglass G. Tomkins, who is retiring after 39 years service, had been both treasurer and comptroller.

The company also named two other officers. **Theodore A. Manning** was appointed assistant treasurer, and **Willard R. Donnelly** was made assistant comptroller.

Glen E. Wilson has been named director of employe relations for Goodrich-Gulf Chemicals, Inc. The company is jointly owned by The B. F. Goodrich Company and Gulf Oil Corporation.

Wilson

Wilson joined B. F. Goodrich in 1928 as an accountant. He served in various positions in Akron until 1942 when he was made personnel manager at the synthetic-rubber plant B. F. Goodrich Chemical Company was operating for the government at Louisville, Ky.

He returned to Akron in 1946 as a member of the company's Employee Relations department. In 1951, he was named director of employee relations for B. F. Goodrich Chemical Company at Cleveland.

John C. Stauffer, patent attorney in the Standard Oil Company (Indiana) Development and Patent department, has retired after 26 years' company service. He also has been associated with Tennessee Corporation and Magnolia Petroleum Company.

W. O. Hoffman has been named superintendent of the Mechanical department at The Atlantic Refining Company's Philadelphia refinery. He succeeds **J. P. McCulley,** who is retiring after 47 years with the company.

J. W. Braun, formerly assistant to the vice president of manufacturing, was appointed superintendent of the Chemicals department.

Other new appointments at the Philadelphia refinery include **A. A. Muse,** named technical assistant to the vice president of manufacturing; **W. E. Chalfant,** made assistant manager of the Product Control department, and **A. J. Ferkel,** assigned to the Chemicals department as assistant superintendent.

R. E. Chaddock, manager of the Sales Research division of Hercules Powder Company's Administrative department, is president-elect of The Chemical Market Research Association. The president of the group is **Edwin M. Otto,** with Pennsylvania Salt Manufacturing Company.

J. William Everson, assistant manager of market research for The Dow Chemical Company, was elected treasurer, and **Robert M. Henderson,** who is senior market analyst for American Cyanamid Company, was elected secretary.

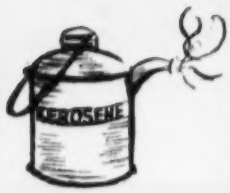
Two new directors were elected for two-year terms. They are **Robert L. Bateman,** director of product development with Carbide & Carbon Chemicals Company, and **James E. Sayre,** manager of market research for Allied Chemical & Dye Corporation's Barrett division.

Gordon W. Duncan, with Esso Research and Engineering Company at Linden, N. J., has been appointed assistant manager in the Office of Scientific Liaison. The office coordinates activities of the re-

reodorize petroleum malodors with Alamask!

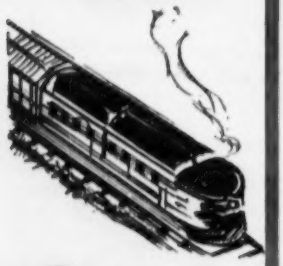
Make olfactorily acceptable petroleum products!

Producers of petroleum products and of petro-chemicals – by adding a selected ALAMASK reodorant – can improve odor characteristics of such materials. A specific ALAMASK is available to achieve adequate reodorization of a variety of petroleum products.



FOR REODORIZATION OF:

FUEL OILS (regular or premium gasoline blends)
KEROSENE
DIESEL OILS
CUTTING OILS and SPECIALTIES
many other petroleum products



Gain olfactory relief with an ALAMASK.

Write, wire or phone for specific information. Our Engineering Section provides complete technical guidance.

Rhodia INC.

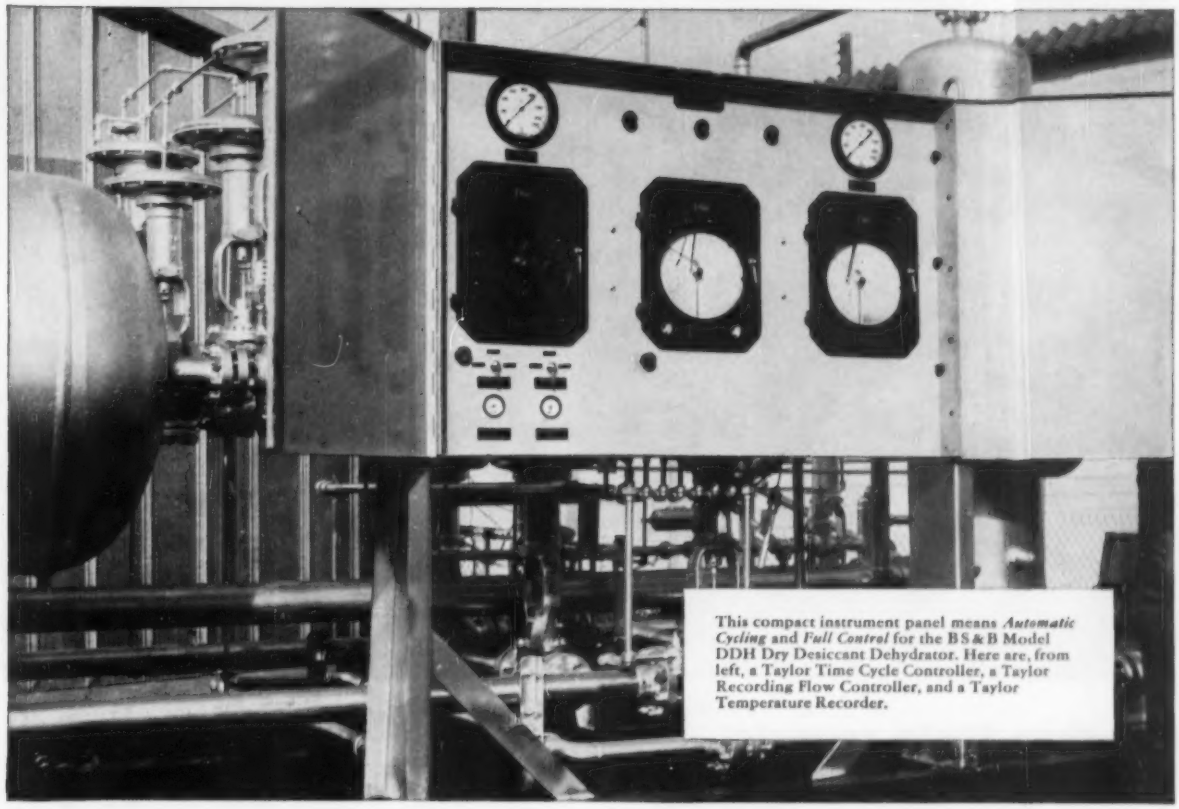
60 East 56th Street, New York 22, N. Y.

PLANT: PATERSON, N. J.

For more data on advertised products, use Readers' Service Cards, last page.

TAYLOR HELPS BS&B PREVENT WATER-VAPOR FREEZE-UPS...

in Natural Gas Transmission Lines!



This compact instrument panel means *Automatic Cycling* and *Full Control* for the BS&B Model DDH Dry Desiccant Dehydrator. Here are, from left, a Taylor Time Cycle Controller, a Taylor Recording Flow Controller, and a Taylor Temperature Recorder.

NOTHING stops the flow of natural gas from well head to consumer like a water vapor freeze-up in the pipe network. The Black, Sivalls & Bryson Model DDH Dry Desiccant Dehydrator prevents these freeze-ups by taking enough water vapor out of the gas so water won't condense out when gas temperature is lowered by pressure reduction or cold weather.

Here's how it works—and here's how Taylor Controls help to make it completely automatic and accurate:

Known for its ability to produce pipeline specification gas when processing gas at high inlet temperature or low inlet pressures, the Model DDH uses two horizontal sorbers packed with adsorptive desiccant—usually forms of alumina or silica minerals. These sorbers work in 8-hour shifts—one adsorbing water vapor from the gas while the other is being reactivated by an inflow of hot gas which removes the water from the desiccant bed. This reactivation gas is heated in a salt bath heater.

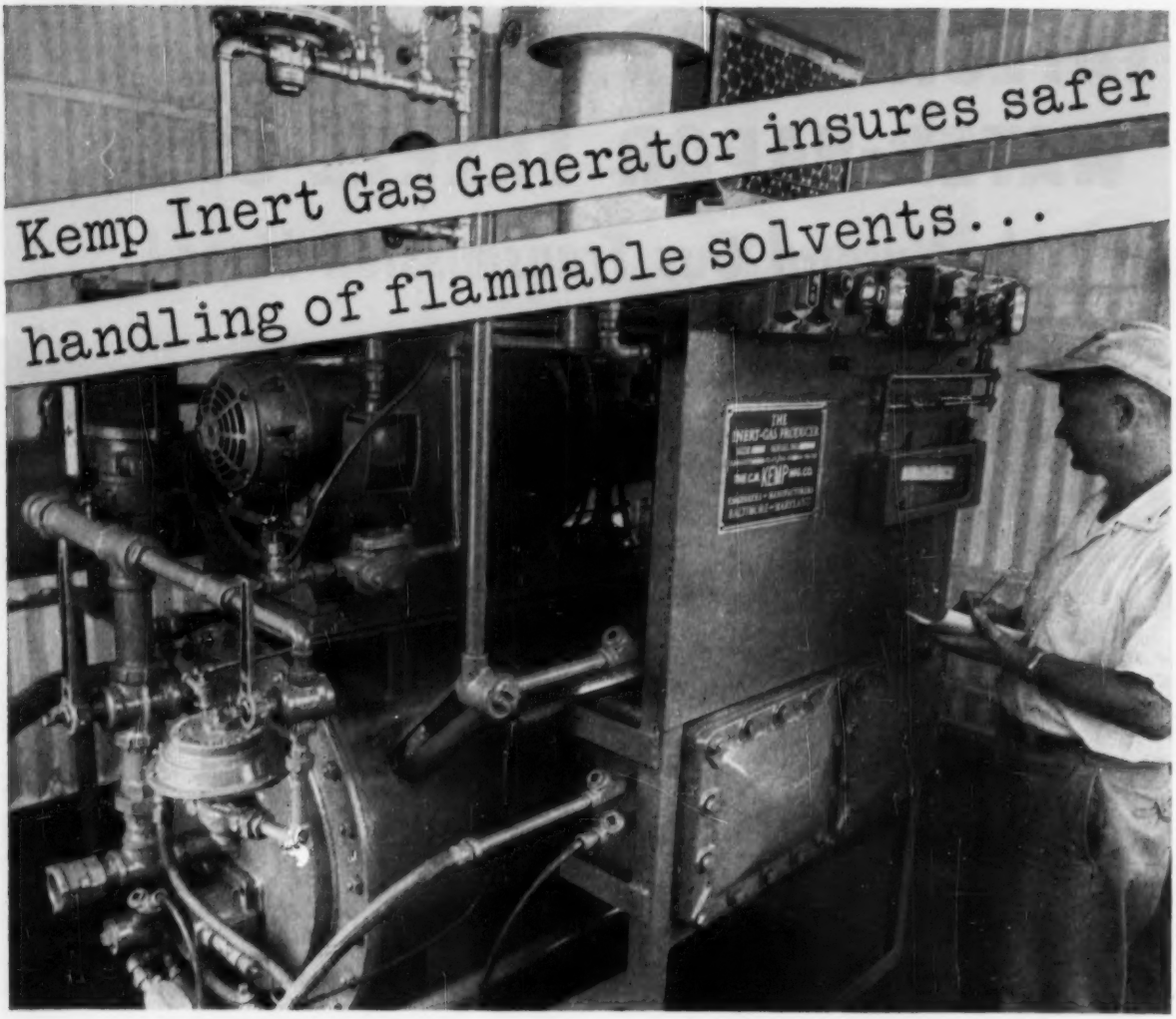
BS&B uses *dependable, accurate Taylor control* because:

- Critical reactivation and drying temperatures must be accurately recorded.
- The adsorption-reactivation cycles must be automatic.
- The reactivation flow rate must be consistently even.
- The heater must be by-passed towards the end of each reactivation cycle to cool the desiccant bed for the next dehydration cycle.
- The switching sequence of the three-way valves must be fully synchronized to prevent back flow, mixing of dehydrated and wet gas or pressure or shock surges which would break down the desiccant.

The Taylor-Controlled BS&B Dehydrator shown here is in efficient service in Texas. To learn more about how Taylor Controls can serve in your oil and gas processing—in any part of the world—call your Taylor representative or write Taylor Instrument Companies, Rochester, N. Y., or Toronto, Canada.

Taylor Instruments MEAN ACCURACY FIRST

For more data on advertised products, use Readers' Service Cards, last page.



Quaker State reports:

Kemp Generator maintains steady inert gas supply for blanketing—even under varying load conditions!

In this Quaker State Oil Refinery, in Farmer's Valley, Pa., a Kemp 3,000 cu. ft. per hr. Generator is used to provide inert gas atmosphere to blanket vessels containing flammable solvents. Mr. Joe O. Brown, Process Engineer, says that the Kemp Generator, in use since 1949, is a big improvement over a previous model replaced by this 3-MIHE.

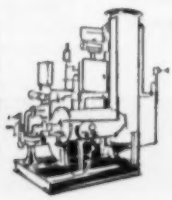
Kemp does all inert gas jobs better

Kemp Gas Generators are easier to operate, start quickly, give continuous output around the clock. Even under fluctuating loads uniform analysis is maintained. Pipelines and vessels can be purged easily, quickly, for cleaning and inspection or when processes are changed! Kemp Generators are also ideal for annealing, hardening, and sintering. Kemp has the ability to produce a chemically clean inert at a specific analysis *regardless* of demand!

Investigate NOW

Find out how Kemp Engineers can provide the most profitable answer to *your* inert gas problem! Write for Bulletin I-10 today.

KEMP OF BALTIMORE



INERT GAS GENERATORS

CARBURETORS • BURNERS • DYNAMIC DRYERS
FIRE CHECKS • METAL MELTING UNITS
SINGEING EQUIPMENT

THE C. M. KEMP MFG. CO.
405 East Oliver Street, Baltimore 2, Maryland

Men in the Industry . . .

search company with universities, institutes, scientific societies and consultants.

Duncan, who joined Esso Research in 1937, had been assistant director of its Products Research division since 1953. He holds B.S. and M.S. degrees in chemical engineering from Pennsylvania State University.

Paul T. W. Strub, formerly assistant to the president of Calor Gas Company in San Francisco, has joined The Fluor Corporation, Ltd., as assistant to the president.

Strub

In addition to his service with Calor, Strub's experience includes six years as a member of the Technical Service staff of Standard Oil Company (New Jersey); a stint with the RFC's Office of Rubber Reserve as manager of the Butadiene and Styrene section, and a year as manager of commercial development with Great Lakes Carbon Corporation.

He holds a B.S. degree in chemical engineering from Bucknell University and a master's degree from Lehigh University.

William H. Johnson and **Edward E. Schilling** have joined the research laboratory staff of The Fluor Corporation, Ltd., at Whittier, Calif. Both are research chemists.

Johnson formerly was chief chemist of the Easton Chemicals Company, Los Angeles, a subsidiary of American Potash & Chemical Corporation. Schilling was senior research chemist at American Potash's Whittier laboratory.

Robert L. Stack has been promoted to group leader in the Analytical division of American Oil Company's Research and Development department at Texas City.

Stack, who previously worked in the Economics and the Process Development sections, started with the company in 1951, following his graduation from the University of Colorado where he received a B.S. degree in chemical engineering.

C. Haines Finnell has been appointed director of public relations and advertising for Union Oil Company of California. The personnel in the Public Relations and Advertising department will remain the same.

A. N. Wohlwend has been appointed director of commercial development for Escambia Bay Chemical Corporation. He was with Stauffer Chemical Company in a similar capacity.

William E. Lifson has been appointed an assistant director of the Products Research division of Esso Research and Engineering Company. He will be in charge of motor lubricants and wax and additives research.

He joined the company in 1945 and was assigned to the Products Research division. He holds several patents in the

PIPING LAYOUT IS SIMPLER with Gentile* FLOW TUBES

...THEY NEED SO LITTLE ROOM

Gentile Flow Tubes are short. They need only minimum straight runs entering and following, and can be installed at practically any accessible point where flow conditions are reasonably steady.

Flow Tubes are furnished with individual head capacity curves, and for unusual piping arrangements, calibration curves for simulated conditions can be furnished.

Guaranteed

- Accuracy
- Minimum Head Loss
- Reproducibility

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FOSTER ENGINEERING COMPANY

835 LEHIGH AVENUE UNION, N. J.

AUTOMATIC VALVES • CONTROL VALVES • SAFETY VALVES • FLOW TUBES

For more data on advertised products, use Readers' Service Cards, last page.

"Greg, it's a shame to let our profits go up in smoke"

"What do you mean? You're talking like we burn money by the bushel basket."

"We might as well. Have you ever stopped to realize how much we're losing by not recovering the pure elemental sulphur that's in the waste hydrogen sulphide from our refining operation?"

"I know it's a waste, but what are we going to do about it?"

"That's what I'm getting at. Let's call in Pritchard. They've got the patented process, the design data, and the specifications. They could get started on our sulphur recovery plant right away."

"Pritchard! We've worked with them before haven't we? Good outfit."

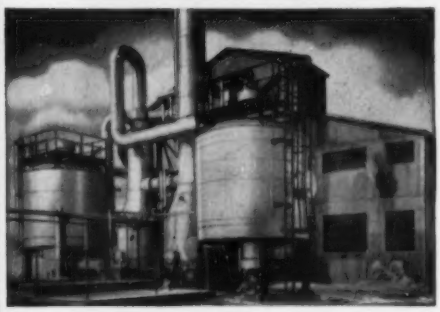
"You bet they are. I know they can do the job. They've got the know-how and experience. How about giving me the green light and let me get a proposal from them?"

"Go to it. And now that you've made your point, you can stop burning."

J. F. PRITCHARD CO.
4625 Roanoke Parkway, Kansas City 12, Mo.

"Greg, it's a shame to let our profits go up in smoke."

Stop Burning Money... Let Pritchard Build Your Sulphur Recovery Plant!



Pritchard can design, engineer and construct a sulphur recovery operation for you that will turn waste into profits.

Waste hydrogen sulphide in your refinery or natural gas operation can easily be converted into valuable, pure elemental sulphur.

Why can Pritchard promise profits from waste? Because Pritchard has the patented processes, practical design data and operating specifications necessary to get the job done right. Pritchard also has another vital advantage — experience!

Write for TIOGA Brochure

TIOGA

You're invited to write on company letterhead for complimentary copy of brochure which illustrates the sulphur recovery plant Pritchard built at Tioga, N. D., for Signal Oil & Gas Co.

INDUSTRY'S PARTNER FOR PROGRESS

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BOSTON, CHICAGO, BUFFALO, HOUSTON, NEW YORK, PITTSBURGH

Men in the Industry . . .

fuels and lubricants fields and is the author of a number of papers on the lubrication of gas turbines and jet engines.

Prior to his new assignment, Lifson was a section head responsibile for research on additives.

Robert E. Wilson, chairman of Standard Oil Company (Indiana), has been named 1956 winner of one of engineering's foremost honors, the Washington Award, sponsored by five leading engineering societies.

Wilson

Dr. Wilson was selected for "unusual dedication of leadership, through science and engineering, to the advancement of research, industry, education and public affairs."

Last year Secretary of Defense Charles E. Wilson received the Washington Award. This is the 33rd time the honor has been presented since it first was given in 1919 to ex-President Herbert Hoover. The award was founded in 1916 by John W. Alvord, a civil engineer, so an outstanding engineer could be recognized by his fellow engineers.

The award commission represents the American Society of Civil Engineers, American Institute of Electrical Engineers, American Institute of Mining and Metallurgical Engineers and American Society of Mechanical Engineers. It is administered by the Western Society of Engineers.

Dr. Wilson has been board chairman of Indiana Standard since 1945. He holds nearly 90 patents and has had more than 100 scientific papers published. He holds several awards and has been awarded honorary degrees by 14 institutions.

L. E. J. Brouwer has been nominated for election as managing director of Koninklijke Nederlandsche Petroleum Maatschappij (Royal Dutch Petroleum Company). He would replace **H. Bloemgarten,** who is retiring.

Brouwer started with Royal Dutch in 1931, when he joined N. V. de Bataafsche Petroleum Maatschappij at the Hague. After several years with the Royal Dutch/Shell Group abroad, he was returned to Bataafsche's head office in the Hague.

In 1954 he was appointed general managing director of Iraanse Aardolie Raffinage Maatschappij (Iranian Oil Refining Company), which, with a producing company, was formed that year to handle production and refining of Iranian oil.

Following his election as managing director of Royal Dutch, Brouwer will be appointed managing director of the parent companies of the Royal Dutch/Shell Group.

Dr. Bloemgarten will be seated as a director of the company.

Anthony J. Bruno, Jr., has been appointed Technical department head at the polyolefin-resine plant W. R. Grace & Company is building at Baton Rouge.

He was chief engineer for Escambia Bay Chemical Corporation at its recently-completed Pensacola, Fla., petrochemical plant. In 1954, he was technical assistant to the director of operations for Olin Mathieson Chemical Corporation at Niagara Falls. Earlier, he was assistant chief engineer of Pittsburgh Coke and Chemical Corporation.

Alvin L. Benham recently completed his Ph. D. degree in chemical engineering at the University of Michigan, and now he has joined The Ohio Oil Company as the first member of its new Research department technical staff. Temporarily assigned to the Los Angeles division, he will be transferred to Denver when the company's new research center is completed there.

George L. Parkhurst, vice president and director of Standard Oil Company of California, has been honored by the Western chapter of the American Institute of Chemists.

The Honor Scroll given to Parkhurst is the highest award that a chapter of AIC can grant to a member of the chemical industry. It was for "his outstanding integration of chemistry and administration in the petroleum and petrochemical industries; for inspiration and guidance in his chosen field, and for his example of achievement to all chemists."

J. Kenneth Craver has become a member of Monsanto Chemical Company's Research and Engineering division in Dayton, Ohio. He will head a special applications research program for the division's Chemical Research department.

For the past two years, Craver has been with General Mills, Inc. Previously he was with Monsanto's Organic Chemicals division in St. Louis

He joined Monsanto in 1938. From 1946 to 1951 he was coordinator of the Organic Chemicals division's development department and in 1951 was made manager of the Special Projects section of that department.

A. G. Edeleanu has been transferred from California Research Corporation to Oronite Chemical Company, to serve as that company's European technical representative. Both companies are subsidiaries of Standard Oil Company of California.

Edeleanu

Before joining California Research, Edeleanu was with The California Texas Oil Company. He served Caltex from 1918 to 1951.

With Oronite, he will make his headquarters in Geneva, Switzerland.

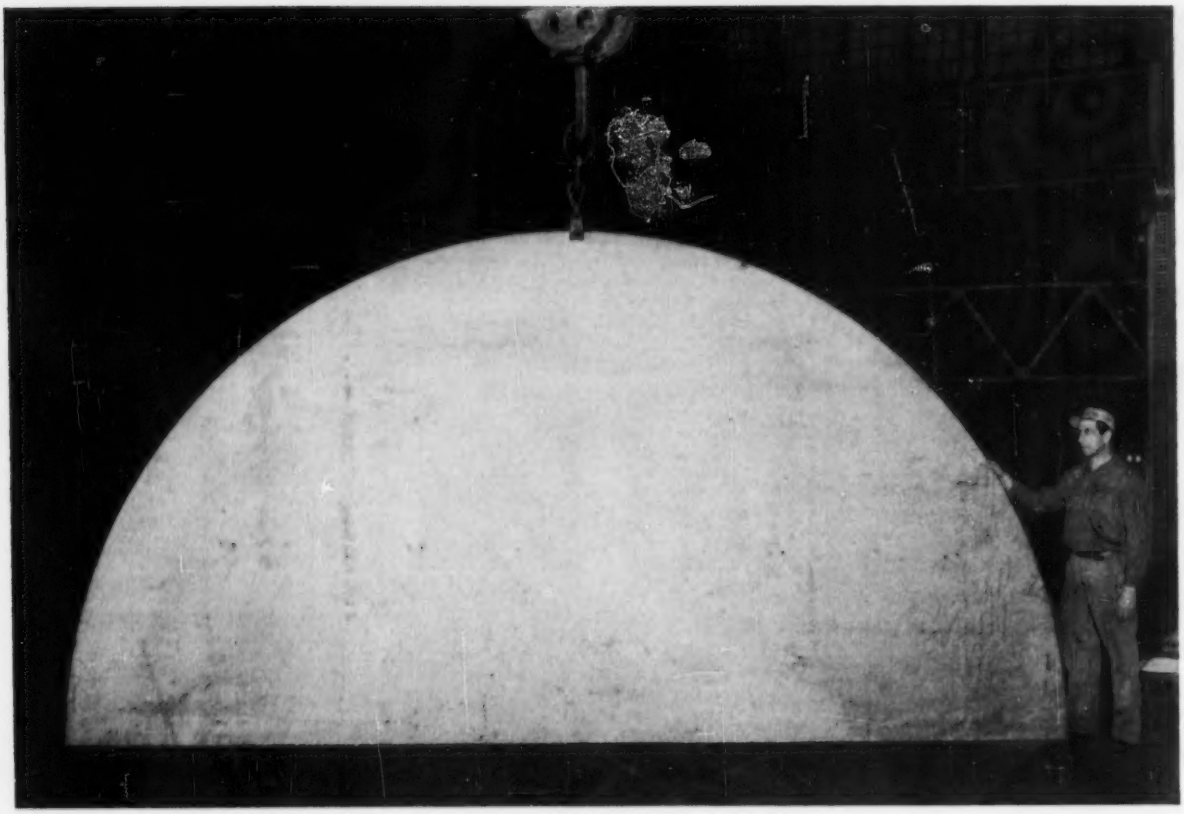
Thomas W. Miller has been appointed executive secretary of the National Lubricating Grease Institute. He will coordinate activities of the institute.

A. P. Beutel, since 1940 general manager of The Dow Chemical Company's Texas division, has been assigned the additional responsibility of constructing and developing the company's new Louisiana division.

Dow is planning to build a plant in the Baton Rouge-Plaquemine area to produce several organic chemicals. The new Louisiana division is expected to require an investment of $20 million.

With the company since 1916, Dr. Beutel was assistant general manager of

For more data on advertised products, use Readers' Service Cards, last page.



Carlson specialized service keeps your costs low

Here's how Carlson *specialized service* in stainless plate worked on this job.

The illustration shows one of two segments of a tank head blank. Made of 1″ thick, Type 302 stainless steel, the head blank measures 210″ in diameter and weighs approximately 9000 pounds. Each segment was produced so accurately the customer did not have to "true up" the abrasive cut straight edges before welding the two segments together. This meant the customer had what he wanted, the way he wanted it—produced to his exact requirements.

And here's why you'll want this *specialized* Carlson service.

More than once we've helped a customer do his job easier, quicker and at lower cost by efficient planning and expert use of specialized equipment. This experience can work to your advantage, too. You can buy *exactly* what your specifications call for—and nothing more. This saves freight charges on material you cannot use. It also saves the cost and trouble of handling scrap in your shop. And you can set up a faster production schedule based on receiving what you want, when you want it.

Stainless steel is our *only* business—and we know it! Let us show you how this *specialized service* can help you. Your inquiry will receive prompt attention.

Stainless Steels Exclusively

G. O. CARLSON, INC.

THORNDALE, PENNSYLVANIA

Plates • Plate Products • Forgings • Bars • Sheets (No. 1 Finish)

District Sales Offices in Principal Cities

Men in the Industry . . .

Dow when he was transferred to Freeport, Texas, to build and operate the Texas division. Previously he had been in charge of building the Ethyl-Dow Chemical Company bromine-from-seawater plant in North Carolina and Dow plants in California which extract iodine from waste brine.

J. R. Stein, assistant general manager of The Dow Chemical Company's Texas division, has been appointed project manager in charge of constructing and developing the company's new Louisiana division. He will carry out his assignment under the direction of Dr. Beutel.

Stein started his career with Dow in 1937, following his graduation from the University of Michigan with a degree in chemical engineering. He was with the Organic Research laboratory and production engineering activities until 1940 when he was assigned to the Texas division. At that time he set up the division's Production Control department. He became assistant general manager in 1943.

James R. Duncan has been elected comptroller and treasurer of The M. W. Kellogg Company. He succeeds **D. J. Olsen** who is retiring after 44 years with Kellogg.

George McCoy has been named manager of Pennsylvania Salt Manufacturing Company's Research & Development department. The department is a major part of Pennsalt's recently-created Technical division.

Dr. McCoy has been with the company since 1944, serving successively as senior research chemist, group leader, assistant director and director of organic chemistry.

Nicholas J. Campbell, vice president of Creole Petroleum Corporation, has been named a director of the company. He succeeds Lloyd G. Smith who retired as vice president and director after 43 years with the company.

W. B. Brooks has been promoted to senior Metallurgist in the Electrochemical Engineering department of The Dow Chemical Company's Texas division at Freeport.

Joining the Texas division in 1948, Brooks was assigned to electrochemical engineering as a research and development engineer. He held that position until his promotion.

L. A. Woodward has been elected administrative vice president of Kerr-McGee Oil Industries, Inc. He was president of Mid-West Refineries, Inc.

Ray F. Granlund, a vice president of Eastern States Petroleum Company, has been advanced to senior vice president in charge of the Refining department. **Marvin A. Bomer,** general manager of refineries, will carry the additional responsibilities of a vice president.

Herbert S. Chase, vice president in charge of manufacturing for Tidewater Oil Company's Eastern division, has retired after more than 34 years with the company. He joined the company in 1922 as a development engineer at the Bayonne, N. J., refinery.

CAMCO

"SPECIALISTS" in

Stainless Steel Pipe Fittings

Shown are a few of the wide range of Stainless Fittings. *Stocked as Standard by CAMCO.*

150# Street Ells Drop Forged to 1" I.P.S. inclusive
Higher sizes machined from castings

150# Bushings Drop Forged to 3" I.P.S. inclusive
Higher sizes machined from castings

Weld Spuds Drop Forged to 2" inclusive
Higher sizes machined from castings

3000# Screwed Tees Drop Forged

150# Union with octagonal ends (over 1" IPS) Drop Forged to 2" IPS inclusive
Higher sizes machined from castings

150# Lightweight Flanges Drop Forged to 2" IPS inclusive
Higher sizes machined from castings

150# ASA Weld Neck Flange Drop Forged

Welding Ells in Schedules 5,10,40 and 80

Cast Flange Fittings to MSS Specification

One source for all your Stainless Steel Fitting Requirements

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CAMCO Products, Inc. 445 State Street North Haven, Conn. PR

Gentlemen:

☐ Please send Flange Dimensional Slide Rule.
☐ Catalog No. 653 covering complete line.
☐ Furnish address of area distributor.

Name ..... Company .....

Address .....

City ..... State .....

THE *Quality* LINE IN STAINLESS

CAMCO PRODUCTS, INC.

445 STATE STREET
NORTH HAVEN, CONN.

For more data on advertised products, use Readers' Service Cards, last page.

What Suppliers Are Doing . . .

Gunning White Siebert McCoy Seiler Glunk

William F. Gunning is an engineer who has joined the new Data and Control Systems department of **Beckman Instruments, Inc.**, as assistant chief project engineer. He formerly was with Douglas Aircraft Company, engaged in developing the first data-handling system for automatically recording strain-gage data. Also assigned to Beckman's new department is **J. Herbert Brown,** who formerly worked on a digit milling-machine project at Massachusettes Institute of Technology.

Arnold B. White has been appointed coordinator of engineering standards for **Carrier Corporation.** He will be responsible for standardization activities carried out in the Engineering Standards department of Carrier's central Research and Development division. White joins Carrier after service as a standards engineer with Veeder-Root, Inc. Before that, he was with Pratt and Whitney Aircraft division.

Carl J. Siebert is the new sales manager of W-S Fittings division of **H. K. Porter Company, Inc.** Siebert, who was district manager in Chicago before his present appointment, has been with the division four years. He joined the company in 1952 as sales representative in the Pittsburgh territory.

Wyn McCoy, formerly district manager for the Industrial division of **The Timken Roller Bearing Company's** Chicago territory, has been promoted to sales promotion manager for the division. He will headquarter at Canton, Ohio. McCoy joined the company in 1940, starting in the Industrial Sales Engineering Training program. He later was sent to the Chicago office and in 1952 became district manager.

John G. Seiler has been elected president of **Tube Turns,** a division of National cylinder Gas Company. He succeeds **George O. Boomer,** who will continue as chairman of the Executive committee of National Cylinder Gas. Seiler joined Tube Turns in 1930. A year later he was made sales manager. He became a vice president in 1941 and general sales manager in 1945. He was elected a vice president of National Cylinder Gas when he was elevated to the presidency of Tube Turns.

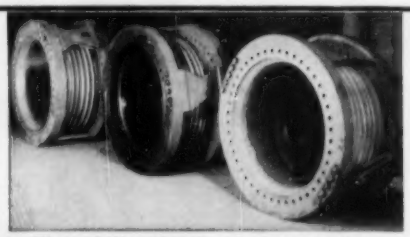
Charles W. Glunk has been appointed chief ceramic engineer of **A. P. Green Fire Brick Company, Ltd.,** a Toronto affiliate of the U. S. concern. He formerly was district sales manager in Richmond, Va., for the Green company. Replacing Glunk in Richmond is **Charles G. Perry,** formerly sales manager for the company in Houston.

Koch Engineering Company, Inc., has made **M. B. Fisher** sales representative for Illinois and Lake County, Indiana. He will headquarter at Park Ridge, Ill. He formerly was with Universal Oil Products Company and Leeds Northrup Company.

Laclede-Christy Company Division, H. K. Porter Company, Inc., has just added a small but complete chemical laboratory which now supplements its facilities for physical testing and petrographic laboratories in providing complete data on raw materials and finished products.

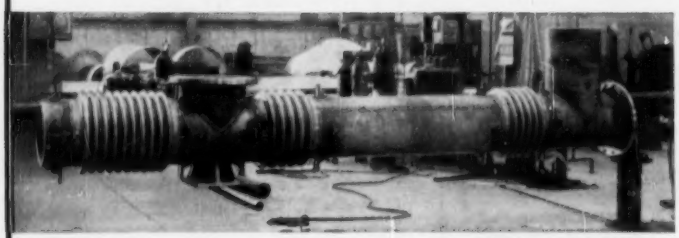
Employing these facilities and a staff of technicians the Research department serves Laclede's Mining, Production, and Sales departments. Mining is provided with proof of the quality of both prospect and in-process clays. Production is fur-

ADSCO



Three 48" Hinge-Type Corruflex Expansion Joints

ENGINEERING BACKS UP EVERY CORRUFLEX PACKLESS EXPANSION JOINT

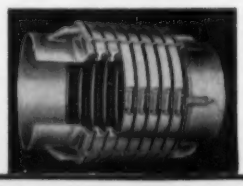


Complex stainless steel assembly of piping and joints absorbing four different motions

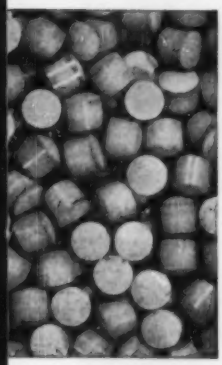
Regardless of size or degree of complexity of the joint involved, ADSCO applies its vast engineering experience to every piping problem presented to it. The help ADSCO provides not only makes the customer's piping react the way it should but also saves money in both installation and maintenance costs. Next time consult ADSCO, a leader in the development of maintenance-free packless expansion joints.

● *Write for Bulletin 35-51.*

Basic Corruflex Joint with Equalizing Rings



AMERICAN DISTRICT STEAM DIVISION
ADSCO INDUSTRIES, INC.
20 MILBURN ST. BUFFALO 12, N. Y.

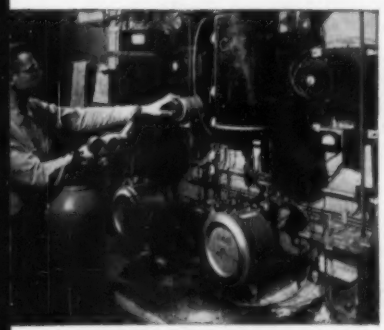


Plus values of Girdler Catalysts

APPLICATION SERVICE
DEVELOPMENT SERVICE
ANALYTICAL SERVICE
MARKET SERVICE
ADVANCED PRODUCTION

A full-scope catalyst service to improve your processing

KEYSTONE of Girdler's co-ordinated catalyst testing work is its development service. Here, highly-skilled technicians work with modern laboratory equipment (like this pilot type autoclave) to create new catalysts and improve existing ones. Girdler's full-scope catalyst service is helping many processors in a wide range of applications boost production and lower costs. Find out how it can work for you to your advantage.



MARKET RESEARCH specialists investigate customer's specific problems and create catalysts to meet their specific needs. They also help develop new end products and improve quality, made possible through better catalysts.

FIELD SERVICE fully complements Girdler's broad catalyst research activities. Girdler's trained specialists work closely with customers at their plants—make sure they get the best possible results from Girdler Catalysts.

FINEST QUALITY and peak performance of Girdler catalysts is assured by our Analytical Service. This vital branch not only monitors our production, but also does valuable "trouble-shooting" analytical work when Girdler customers encounter problems.

CATALYST DEPARTMENT

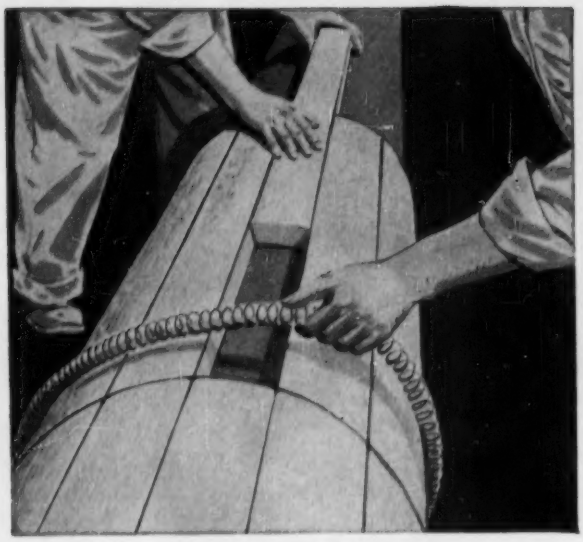
The GIRDLER Company

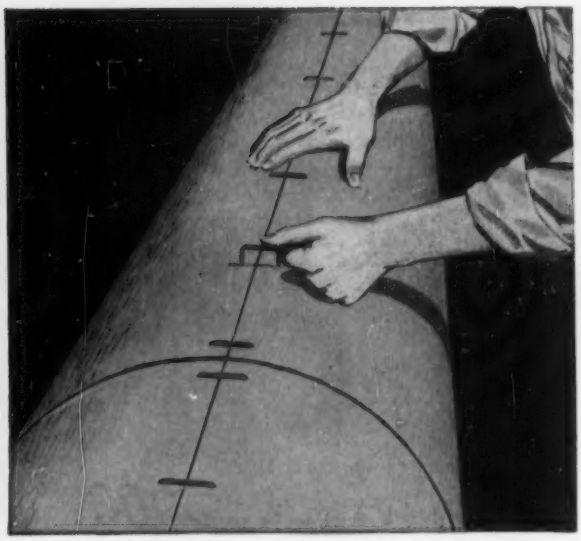
A DIVISION OF NATIONAL CYLINDER GAS COMPANY

LOUISVILLE 1, KENTUCKY

GAS PROCESSES DIVISION: New York, San Francisco **VOTATOR DIVISION:** New York • Atlanta • Chicago • San Francisco

In Canada: Girdler Corporation of Canada Limited, Toronto





Why handle **24,948** insulation segments?...

...when you can do the job with **1,134** sections

SNAP*ON **GLASS FIBER PIPE INSULATION** vs. segmental insulation — that was the question at an eastern refinery where more than a mile of 16" pipe and its accompanying steam tracer line required insulation. A comparison of Snap*On vs. segmental yielded the following information:

- Since Snap*On comes in *one-piece 6' sections*, the number of Snap*On sections would total only *1134*. To do the same job with segmental insulation would have required handling and applying *24,948 curved segments 3' long.*
- Because of Snap*On's flexibility, standard 20" one-piece sections could be used to cover both pipe and steam tracer lines in one easy operation. No special cutting, fitting or equipment would be required; not so with segmental insulation.
- Snap*On has the highest thermal efficiency of any pipe covering on the market. In addition, since joints between segments are a potential source of heat loss, Snap*On's single joint construction gives it a decided thermal advantage, especially on large pipe sizes.
- Since Snap*On is almost immune to damage in transit, storage and application, no extra pieces would need to be ordered for breakage — and no allowance made for clean-up time. (You can readily estimate breakage and clean-up time required when using segmental insulation.)

But prove to yourself just how economical G-B Snap*On is by making similar comparisons in your plant whenever hot or cold piping from ¾"-33" requires insulation. In the meantime —

WRITE FOR FREE COPY OF NEW 8-PAGE BROCHURE

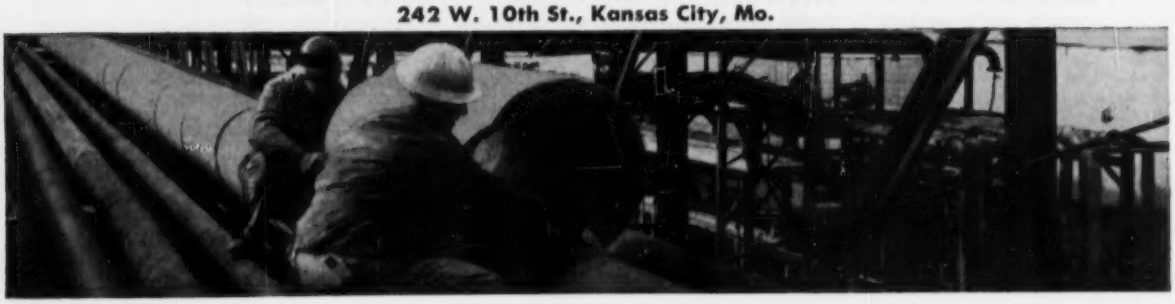
*Manufactured under U. S. Patent 2,743,340. Other patents pending.

GUSTIN-BACON *Manufacturing Company*

GUSTIN gb BACON

Thermal and acoustical insulations • Molded glass fiber pipe insulation • Pipe coupligs and fittings

242 W. 10th St., Kansas City, Mo.



Suppliers . . .

nished final mix sheets with recommended instructions as to proper blending, grain sizing, shrinkage, and firing. Quality control within the factories, and testing in the laboratory help maintain these standards. Sales is kept informed of new technical information on both Laclede products and competitive products.

Alan Wood Steel Company has appointed **Harold E. Taylor** as superintendent of its Coke and Chemicals department. He succeeds **Paul C. Mayfield,** who is retiring.

Taylor came with the company as general oven foreman in 1929 and was made assistant superintendent of the Coke and Chemicals department in 1945, which position he held until his present appointment.

U. S. Steel Corporation has created an executive committee. **Clifford F. Hood,** president of the company, will serve as chairman of the committee.

An Executive Advisory committee created a year ago was discontinued. Former president and chairman of the board, **Benjamin F. Fairless,** who had been chairman of the Executive Advisory committee, will, in addition to his duties as a consultant, serve as special advisor to the board of directors.

The Griscom-Russell Company, a subsidiary of General Precision Equipment Company, has joined with Schack Rekuperator Company, a Dusseldorf, Germany, concern, to form Griscom-Russell-Schack Company, Inc.

The new company will maintain headquarters and main sales offices in Pittsburgh, under the direction of **T. E. Dixon,** vice president in charge of sales, and Heinz Kuhne, vice president in charge of design and engineering.

ALCO Products, Inc., is assigning **Del Thoman** to the San Francisco area as its sales representative. Thoman, a 1950 graduate of the U. S. Merchant Marine Academy, was a field representative for Alco in its Central and Southwestern Regions before entering the Navy two years ago. He recently was released from active duty.

With the Navy, he served a year as assistant industrial manager at Seattle, and a year as assistant resident supervisor of shipbuilding at Bellingham, Wash.

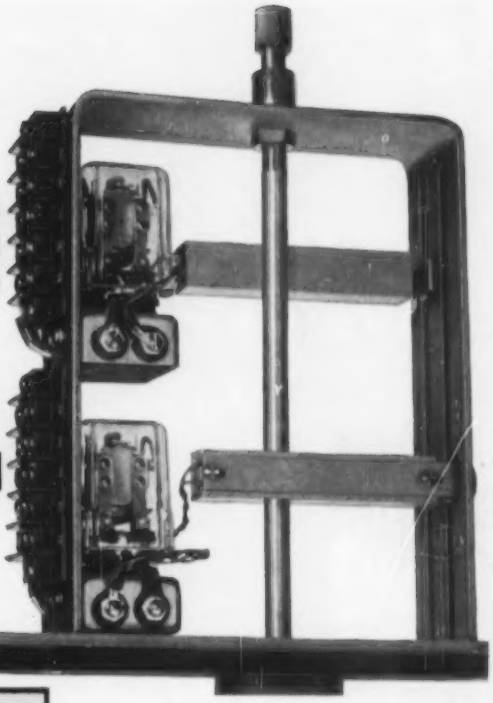
General Electric Company has named **Andrew L. Kozak** as superintendent of manufacturing for its Gas Turbine department Kozak has been with the company since 1948.

Following service at the Philadelphia and Lynn River works, Kozak became associated in 1949 with the Gas Turbine department and worked on the design and development of gas turbines. In 1953 he was made supervisor of factory production and liaison in the department's Engineering section.

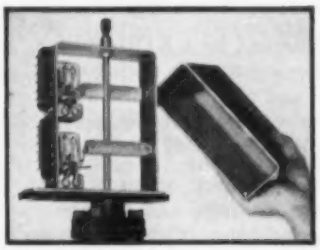
Beckman Instruments, Inc., has assigned to its International division responsibility for the exporting activities of all its manufacturing divisions.

Divisions affected include the Arga and Helipot divisions of South Pasadena, Calif.; Berkeley, Richmond, Calif.; Spinco, Bel-

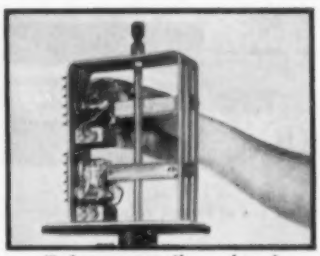
VIBRATION *proof* FLOW ALARM



Ratolarm with cover on



Ratolarm with cover removed



Relays are easily replaced

At last a low cost flow alarm immune to vibration. For linear scale flowmeters and liquid level applications.

Snap-action electrical contacts are hermetically sealed in glass. Contact closure can be made *only* by passage of the magnetic float extension rod. False alarms are eliminated.

Consider these advantages:

- Rugged, vibration-proof, glass-sealed switch
- High, low or double alarm, adjustable to any scale position
- Dependable, long life, low cost, no electronic parts
- Explosion-proof construction available
- Plastic enclosed plug-in relays for easy maintenance

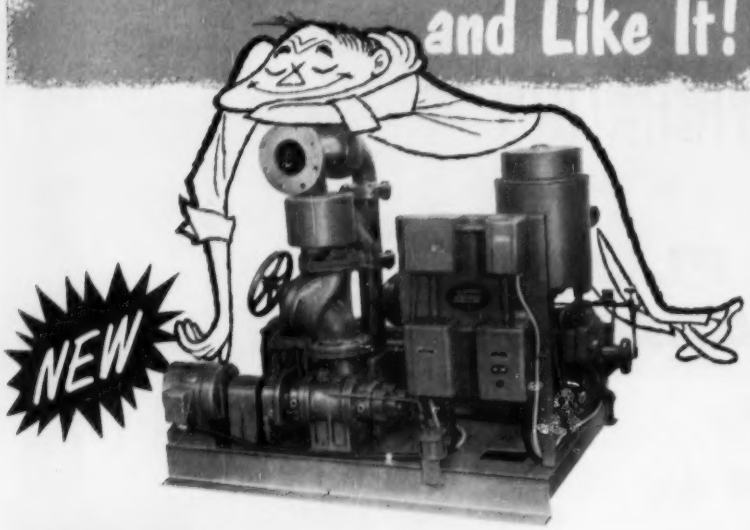
Write today for complete information. Ask for catalog 10-A-84.

FP FISCHER & PORTER CO.

LA1086 966 County Line Road, Hatboro, Penna.

For more data on advertised products, use Readers' Service Cards, last page.

Be "Thoroughly Exhausted" and Like It!



Kinney®

KMB-230 MECHANICAL VACUUM BOOSTER PUMP EVACUATES LARGE VOLUMES IN RECORD SPEED!

The Kinney KMB-230, the latest addition to the world's largest line of High Vacuum Pumps, offers the same design principle and general characteristics as the performance-proved KMB-1200. Even combined with any of several mechanical vacuum pumps, 18 CFM or larger—depending upon application requirements, it makes an extremely compact pumping unit. It can be conveniently installed as a vacuum line "booster", has a low power consumption of only 2 HP at 3600 RPM, a high staging ratio, and forepressure of 75 mm Hg.

The unit illustrated shows a KMB-230 backed by a KDH-130 for the speedy evacuation of large volumes prior to leak testing with mass spectrometer. Its high speed feature and ability to handle "gas bursts" without stalling make it ideal for vacuum furnace applications . . . and many others. Request complete data today!

Contact any of our competently staffed district offices . . . in Baltimore, Charleston, W. Va., Charlotte, Chicago (La Grange), Cleveland, Detroit, Houston, Los Angeles, New Orleans, New York, Philadelphia, Pittsburgh, San Francisco, St. Louis, or The International Sales Office, 90 West St., New York 6, N. Y.

KINNEY MFG. DIVISION
THE NEW YORK AIR BRAKE COMPANY
3596 WASHINGTON STREET • BOSTON 30 • MASS.
INTERNATIONAL SALES OFFICE, 90 WEST ST., NEW YORK 6, N.Y.

Kinney

• **Please send Catalog No. 425** describing the complete line of Kinney Vacuum Pumps.

Name.....

Company.....

Street.....

City..... *State*.....

Suppliers . . .

mont, Calif.; Liston-Becker, Stamford, Conn., and the Scientific Instruments Division, Fullerton.

Publication of an International Division Bulletin, supervised by Salesmanager **Robert T. Jones**, has been instituted for representatives throughout Western Europe, Africa, Latin America, Asia, Australia, and New Zealand.

Climax Molybdenum Company has appointed **Robert R. Freeman** manager of arc-cast molybdenum development.

Prior to joining Climax, Freeman had been with Westinghouse Electric Corporation in various engineering and supervisory capacities since 1940. During this period he was engaged in production and in the development of new uses for molybdenum and tungsten. He is the author of a number of technical papers on high temperature applications of molybdenum.

In his new capacity, he is responsible for the development of new applications for metallic molybdenum and molybdenum-base alloys.

Tube Turns President **John G. Seiler** has been appointed to the Nuclear Energy group of the Southern Regional Education Board sponsored by the Southern Governors' Conference. The appointment was made by Governor A. B. Chandler of Kentucky.

The Nuclear Energy group is composed of leading industrialists and specialists in medicine, agriculture, manpower and education. It will study peacetime applications of nuclear energy in the South.

The Dow Chemical Company has **J. W. Britton** relinquishing his duties as a departmental production manager in the Midland division to devote full time to company-wide responsibilities as manager of Agricultural Chemicals. He had held the production post since 1944.

Succeeding Britton as departmental production manager is **Ralph F. Prescott** who will also replace him as a member of the Midland Division operating board. Prescott has served as assistant production manager since 1949.

As a production manager, Britton headed production of a group of organic and agricultural chemicals and latexes for the past 12 years. He has also been manager of Agricultural Chemicals for seven years. The new arrangement will enable him to give full attention to increasing administrative duties.

Britton, who came to Dow in 1923, served 11 years with the Organic Research laboratory, the Coumarin-Salol, Benzoic Acid and Phenacetin plants and as a production "trouble shooter." He became superintendent of the Organic Semi-plant in 1934, holding this post until his appointment as a departmental production manager.

Prescott has been with the company since 1928. During his career he has been associated with Britton for many years in laboratory and production areas.

Climax Molybdenum Company and Mallinckrodt Chemical Works have reached an agreement to submit to the Atomic Energy Commission a joint proposal for the construction and operation of a privately-owned plant for the refinement of uranium compounds.

The agreement states that in the event the proposal is accepted a jointly-owned

For more data on advertised products, use Readers' Service Cards, last page.

Suppliers . . .

company would be formed to construct and operate such facilities. Under terms of the agreement Climax would be majority owner of the resultant company.

Automatic Switch Company has started grading and excavation for the erection of a new plant at Florham, N. J. The new facilities will have double the capacity of the ASCO plant at Orange, N. J.

The company expects to move its entire operation to the new location by the end of 1956. The one-story building, with 120,000 square feet of floor area, will occupy a 30-acre site in the suburban area about 15 miles west of Newark, and some 10 miles from the present factory.

Chicago Bridge & Iron Company has transferred **N. Casey Iler, Jr.**, to its Cleveland sales office, and **Oliver E. Norris** has been assigned to the company's New York sales office.

Iler joined the company's Pacific Coast Erection division in 1953; Norris started with the company in 1952 as a member of its Chicago Engineering department.

The Bird-Archer Company has moved all facilities from New York to the company's headquarters in Philadelphia. A new laboratory, recently completed, doubles Bird-Archer's capacity to carry on tests and research.

Elliott Company has named **H. A. Erb** as works manager for its Steam division at Jeannette, Pa. He will be responsible for manufacturing of turbines, condensers, heaters, compressors, strainers, ejectors and turbochargers.

Erb joined Elliott Company in 1928. He has held various plant positions and been division engineer for the Compressor division for the past several years.

Gustin-Bacon Manufacturing Company has appointed a new sales representative for its Industrial department. He is **Sheldon Schultz**, who will represent the company in Texas, Oklahoma and Kansas. He formerly was with The Mud Products Company.

Ethyl Corporation has taken options on land near Joliet, Ill., as a possible site for a new antiknock-compound manufacturing plant.

Ethyl Corporation owns plants in Baton Rouge, La., and Houston, and its subsidiary, Ethyl Corporation of Canada Ltd., is building a plant near Sarnia, Ont.

National Aluminate Corporation has elected **J. A. Holmes** president. He succeeds **H. A. Kern**, a founder of the company, who continues as chairman of Nalco's board of directors. Nalco's first chief chemist, Holmes has been with the company since its beginning.

Frank H. Thorne, retiring senior vice president, retains his post as vice chairman of the board. Vice President **H. R. Powers** takes over as manager of the Industrial division of National Aluminate, the position formerly held by Holmes.

The Pfaudler Company has established two scholarships of $2000 in the Department of Metallurgical Engineering

at the frontiers of progress you'll find . . .

AN AIR REDUCTION PRODUCT

Here's the easiest "do-it-yourself" project you ever undertook . . .

Installing COLFOAM MICROBALLOON* Spheres for Big Savings in Cone-Roof Crude Oil Tankage

Installing a blanket of Colfoam Microballoon Spheres in cone-roof tanks is easy— so easy you can do it yourself. And the results of installing this Colfoam Microballoon Spheres blanket are dramatic. Evaporation losses are immediately cut by as much as 86%.

Colfoam Microballoons, exclusive with Colton Chemical Company, are microscopically-small, gas-filled spheres made of urea formaldehyde, which float on the surface of stored crude oil to form a foam-like seal. They soon pay for themselves in the amount of stored material they save.

Complete Colton technical service, *at no additional cost*, surveys your storage problems, estimates the quantity of Colfoam Microballoon Spheres needed, supervises initial installation. Helpful instruments are supplied—a Portable Gage Tape Well assists in accurate readings of the amount of crude stored and a Foam Sampler measures foam thickness.

Write today for full information, for facts-and-figures proof of substantial savings through efficient evaporation control.

*COLFOAM Reg. T. M. Colton Chemical Co. MICROBALLOON Reg. T. M. Standard Oil Co. (Ohio)

COLTON

COLTON CHEMICAL COMPANY

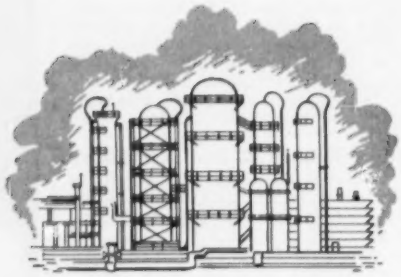
A DIVISION OF AIR REDUCTION COMPANY, INC.

1747 Chester Avenue • Cleveland 14, Ohio

Sales Offices and Warehouse Facilities Throughout U. S.

Export: Airco Company International, New York 17, N. Y.

Products of other divisions of Air Reduction Company, Inc. include: AIRCO—industrial gases, welding and cutting equipment PURECO—carbon dioxide, liquid-solid ("DRY-ICE") OHIO—medical gases and hospital equipment NATIONAL CARBIDE—pipeline acetylene and calcium carbide.



DESIGN
ENGINEERING
CONSTRUCTION

A DIVISION OF VITRO CORPORATION OF AMERICA

The REFINERY ENGINEERING Company

NEW YORK TULSA TORONTO

Suppliers . . .

of Ohio State University. The scholarship awards provide $500 a year for four years to the two selected students.

One scholarship will be awarded during each of the even numbered years, which means a selection will be made this summer. The awards are made by the company to encourage worthy young engineering prospects to enter the field of metallurgy.

In 1954, two similar $500 a year scholarships in the field of ceramics were established by Pfaudler at Pennsylvania State University. The study of glass, porcelain, enamel, clays and abrasives are a few of the areas in this field that get concentrated attention at the Ceramics division of the College of Mineral Industries at Pennsylvania State University.

Pfaudler also contributes support to postgraduate research at both Rensselaer Polytechnic Institute and the University of Rochester, bringing to four the number of engineering schools helped by the company. The contribution at both schools is in the form of a research grant with distribution of funds left entirely up to the faculty.

Davison Chemical Company, Ltd., Canadian affiliate of Davison Chemical Company Division of W. R. Grace & Company, has named **William B. Davis** manager of the $6-million plant it has under construction at Valleyfield, near Montreal, for the production of synthetic fluid petroleum cracking catalysts.

Davis

The plant is scheduled for completion in April, 1957.

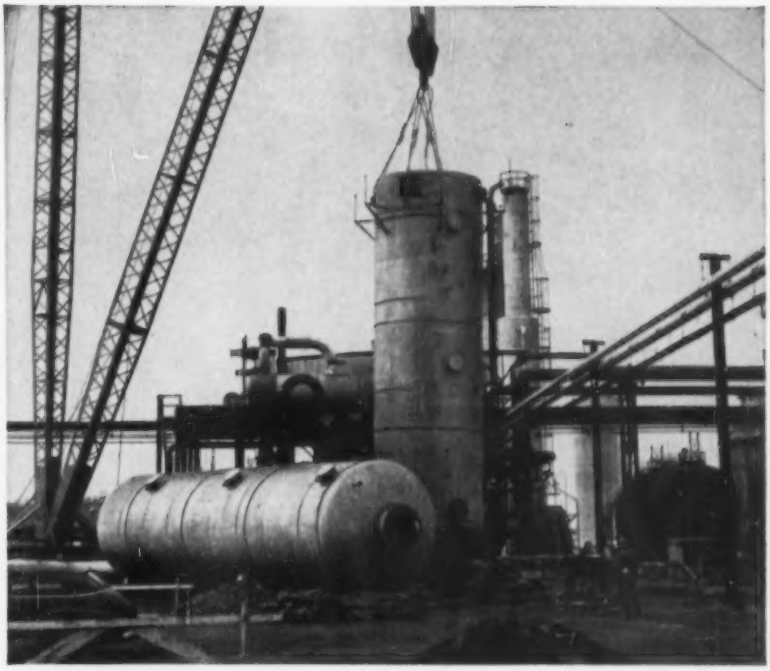
Davis has been staff assistant to the company's vice president for operations. After work in research and control testing at Seaboard Asphalt Company of Baltimore, he joined Davison in 1942 as control engineer. He subsequently was superintendent of the company's sulphuric-acid plant at the Curtis Bay Works, and before becoming staff assistant he was production manager at Curtis Bay.

The Pfaudler Company has held its 100th technical meeting on maintenance and operation of glassed steel and alloy process equipment. The meeting, held in Houston, was conducted by **B. G. Staples,** from the company's research laboratory at Rochester, N. Y.

Maintenance supervisors, foremen, superintendents and engineers from nearby plants attended. This was the second time such a meet had been held in Houston.

Borax Consolidated, Ltd., will form a new company to take over the greater part of its assets and operations in the U. S. The transfer has been approved by the British government.

When the reorganization is completed, the new U. S. corporation will hold the parent company's boron deposits at Boron, Calif., with its factories for the production of boron, boric acid and organic and inorganic boron compounds. The existing company has a program underway at



More than 86,680 welds in complex column by Downingtown

Diameter: 11′ 11″ I.D.

Total Height: 93′ 11″.

Material: Stainless steel, Type 304. Carbon steel skirt and base ring.

Shell Thickness: ½″ and ⅜″.

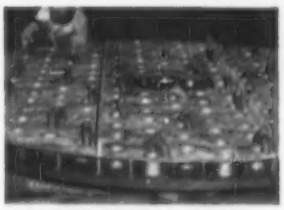
40 Trays and downcomers. 177 bubble caps and risers on each tray.

Code Stamping: National Board and ASME. Sandblasted and pickle washed.

Downingtown welders completed more than 86,680 separate stainless steel welds during fabrication of this stainless steel column. Tolerances of ±⅛″ . . . ±1/16″ . . . even ±1/32″ . . . were maintained in the shaping, positioning and welding of thousands of stainless steel parts. Lapsed time from drawing board to final field testing: less than six months.

Send for Bulletin PF. It tells the story of Downingtown skill and experience that enable us to breeze through complex fabrication jobs like this one.

Field tested by Downingtown... inspected by customer and Hartford...Code stamped on location.



Special jig for welding stainless steel risers to stainless steel tray.

Downingtown Iron Works, Inc.

HEAT EXCHANGERS—STEEL AND ALLOY PLATE FABRICATION

151 Wallace Ave., Downingtown, Pennsylvania—Branch Offices:

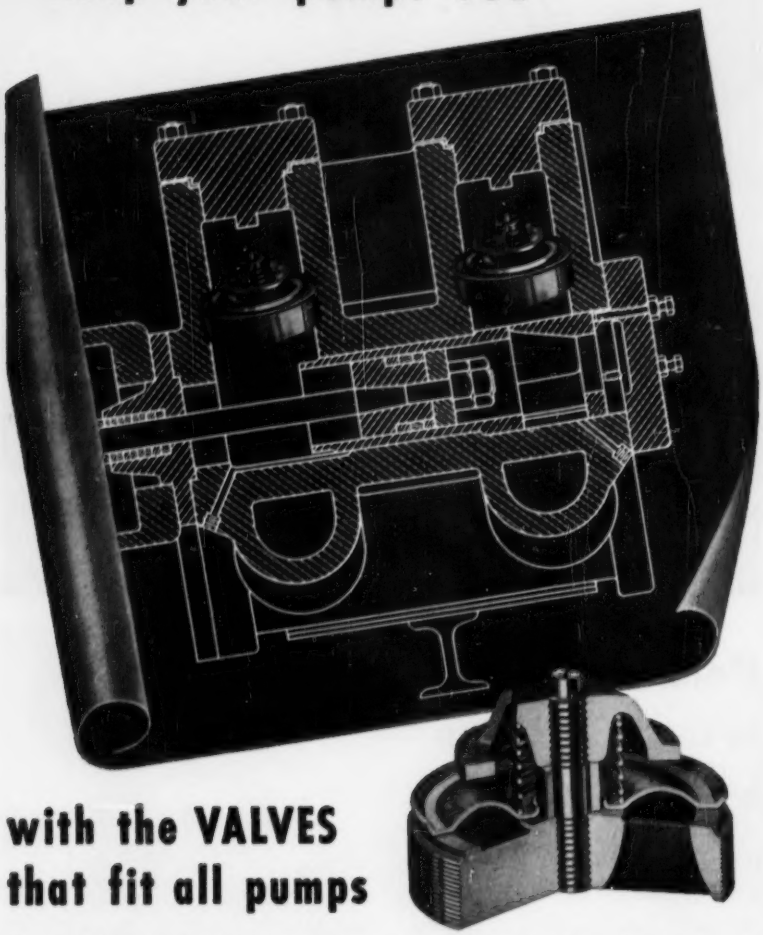
1435 S. 66th St., Milwaukee 14 • 52 Vanderbilt Avenue, Room 2014, New York 17 • 215 Henna Bldg., Cleveland 15 • 936 W. Peachtree St., N.W., Room 119, Atlanta 3 • 208 S. LaSalle St., Room 783, Chicago 4 • 560 Roosevelt Bldg., Los Angeles 17 • 4550 Main St., Room 217, Kansas City 6, Mo. • 151 Wallace Ave., Downingtown, Pa.

DOWNINGTOWN IRON WORKS INC. Hackney

CONTAINERS AND PRESSURE VESSELS FOR GASES, LIQUIDS AND SOLIDS

For more data on advertised products, use Readers' Service Cards, last page.

Keep your pumps FIT



with the VALVES that fit all pumps

Your old reciprocating pumps can be rehabilitated or adapted to new and severe service by fitting them with DURABLA Pump Valve Units.

The patented corrosion-resistant, non-warping, pressed metal valve, making only "point contact" on the stud or sleeve, cannot bind or hang up on the guard stem. The open-type guard assures free flow of liquid and eliminates any possibility of spring clogging from hardening liquids.

DURABLA Pump Valves will operate freely under extremes of high or low temperature, with highly corrosive fluids, and in any position. They will handle vacuums of one micron or discharge pressures of thousands of pounds per square inch.

Standard equipment on many pumps, DURABLA Valve Units are made in fifteen sizes, designed to meet over 300 variations in installation requirements. They will fit any reciprocating pump, new or old.

A DURABLA engineer will be glad to help you work out a plant survey covering your valve requirements. Write for bulletin or engineering assistance.

DM-2

DURABLA®

DURABLA MANUFACTURING COMPANY

114 LIBERTY STREET • NEW YORK 6, N. Y.

Suppliers . . .

Boron to expand and modernize its facilities there by converting the mine to open-pit operations and increasing the plant's capacity.

This program, expected to be completed in the second half of 1957, will cost some $18 million. Financial arrangements to cover the cost have been made with Equitable Life Assurance Society, Chase Manhattan Bank and Los Angeles' Farmers and Merchants National Bank.

Bratton

Clarke

The M. W. Kellogg Company has made two new additions to its staff. They are **W. E. Bratton** and **Ralph L. Clarke**, who will represent the company in the administration and handling of engineering and construction contracts in the petroleum and petrochemical fields.

Bratton formerly was head of the Contract department of The Lummus Company. Prior to his appointment to this position in 1953, he had served as Lummus's special representative in Washington for two years. Before his Washington assignment, he had served with the Air Force.

Clarke was with the Badger Process division of Stone & Webster Engineering Corporation. A petroleum engineer, he has had extensive design and operating experience in the petroleum-refining, petrochemical and natural-gasoline industries in Oklahoma and the Texas Gulf Coast as well as in the United Kingdom. He was associated previously with the Gasoline Plant division of American Republics Corporation, Houston.

Fisher Governor Company has purchased Control Specialty Company, Houston manufacturer of lease automation equipment, switches and related equipment. Plans call for an expansion of the Houston plant. Control Specialty will be operated as a subsidiary of Fisher Governor.

U. S. Steel Corporation has assigned four field representatives to new locations for its Oil Well Supply division. In addition, the company has selected a new district representative, a new store manager and city representative. These are the new field representatives:

- **John W. Porter** was named field representative at Abilene, Texas. He joined the company in 1948 at Wichita Falls, and two years later was transferred to Abilene, where he was serving before his present appointment.
- **James M. Ireland** was transferred to Huntington Beach, Calif., from Long Beach. Ireland had been at Long Beach since he joined U. S. Steel in 1948.
- **Billy E. Smith**, who was with the Oil Well Supply division at Huntington Beach, was assigned to Ireland's old post in Long

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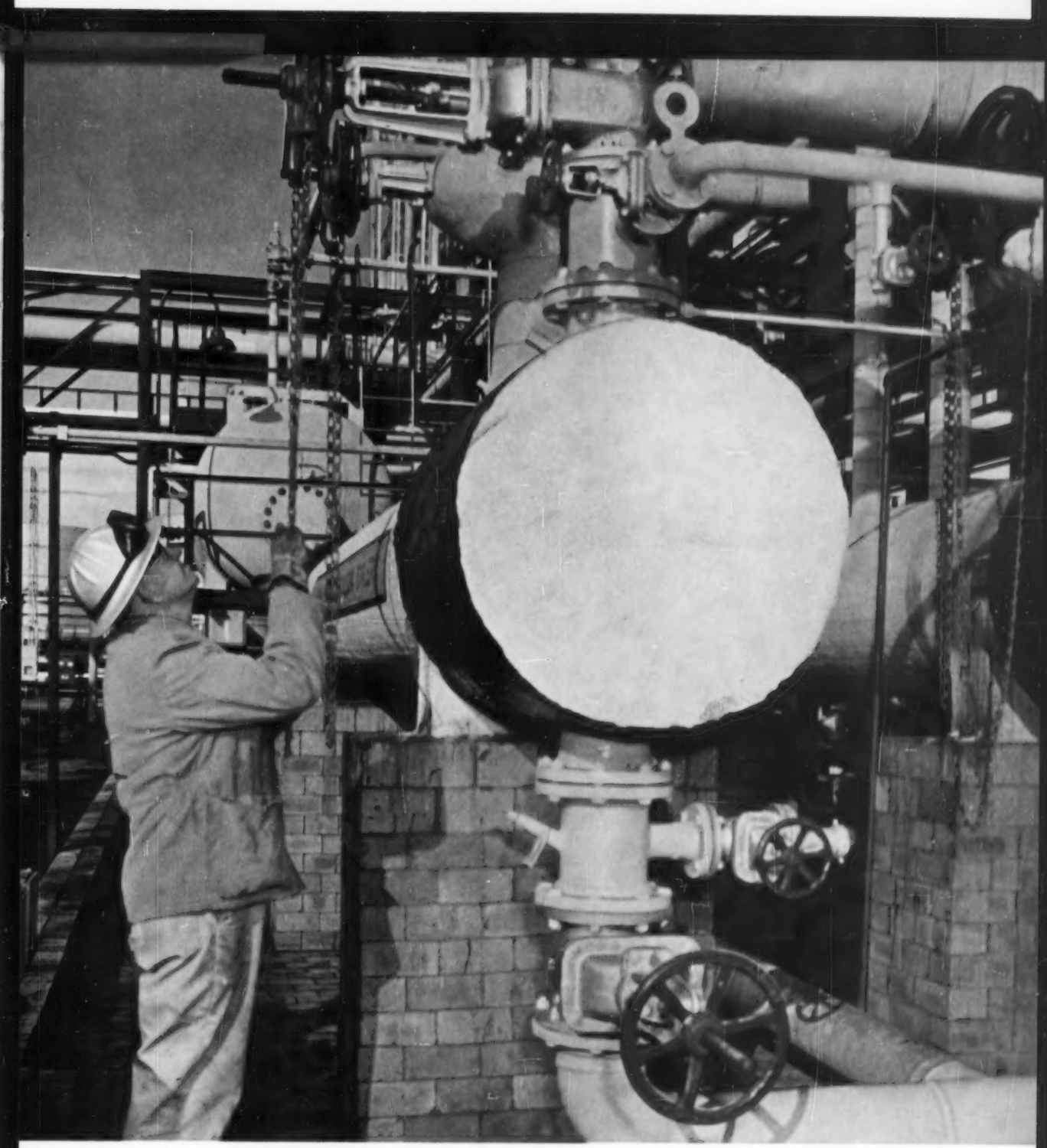


Closing the gate on hard-to-hold hydrocarbons

At Esso Standard Oil's Bayway Refinery light hydrocarbons are used extensively at a wide range of temperatures and pressures.

Light hydrocarbons are hard to "hold," but the self-adjusting wedge design on Aloyco gate valves insures tight shut-off. Corrosion-resistant Aloyco valves – like the red-wheeled, chain-operated gate valve above – are used throughout many process units.

You'll see many more of them on key jobs at leading petroleum, processing and chemical plants throughout the country. What about your corrosives-handling problems? Write Alloy Steel Products Company, Inc., 1301 West Elizabeth Avenue, Linden, New Jersey.

6.2

Longer Lasting
ALOYCO
VALVES
TRY IN CORROSIVE SERVICE

Subsidiary of Walworth Company

What is Jersey Standard?

PEOPLE. The more than 300,000 people who own it—merchants . . . teachers . . . farmers . . . bus drivers . . . housewives . . . people who've invested their savings in our growth. They have just received the Annual Report on the 73rd year of our company's business.

What makes Jersey Standard run? People. People in offices and in the labs, in the oil fields and refineries of our affiliated companies. People like all of us . . . who work, play, raise families.

What keeps Jersey Standard and its affiliates in business? All kinds of people — stockholders, employees and customers.

Because of all these people, we had a good year in '55. A year of searching for and finding more oil to provide light and heat, to run cars and trucks, trains and planes, buses and tractors, to make petrochemicals. A year of even greater research leading to more and better products. A year—as our Annual Report shows — of better sales and earnings, of record payments in wages and benefits to employees, of record income generated for governments in the form of taxes — a year, in short, of bigger contributions to the prosperity of the people of the countries where we do business.

If you would like a copy of our 1955 Annual Report to Stockholders, please write to us at: Room 1626, 30 Rockefeller Plaza, New York 20, N. Y.

STANDARD OIL COMPANY (NEW JERSEY) AND AFFILIATED COMPANIES

For more data on advertised products, use Readers' Service Cards, last page.

Suppliers . . .

Beach. He started with the company in 1947 at Coalinga, Calif. In 1950 he was appointed field representative at Bakersfield and in 1953 transferred to Huntington Beach, where he was working prior to his new appointment.

• **Norman E. Cordell,** who was field representative for the division at Vlay City, Ill., was transferred to Matton, Ill. With the company since 1950, he has served at Salem and Fairfield, Ill., and at Clay City, where he had been field representative since 1953.

The company's new district representative at Taft, Calif., will be **Arne S. Johnson,** who held a similar post for the Oil Well Supply division at Bakersfield. Johnson joined the company in 1950 at Avenal, Calif.; he was transferred to Bakersfield in 1951 as field representative, and he was appointed district representative there in 1955.

Named as manager of the Oilwell store at Fairfield, Ill., was **Harold E. Reeves.** With the company since 1948, Reeves had been a field representative at Fairfield since early this year.

Frank J. Long, who had been field representative at Casper, Wyo., since 1954, was named city representative there. He started with U. S. Steel in 1949, later serving in Montana, North Dakota and Colorado.

Olin Mathieson Chemical Corporation is scheduling a $7.5-million expansion program to double electrolytic production of chlorine and caustic soda at its McIntosh, Ala., plant.

The expansion will increase the plant's capacity to 250 tons of chlorine and 280 tons of caustic soda a day. Construction, which is already under way, is being handled by the Blaw-Knox Company, with completion scheduled for January, 1957.

The new addition will be equipped with 124 of the latest design stationary-type mercury electrolytic cells. The cells produce chlorine, caustic soda and hydrogen by passing an electric current through a solution of common salt.

The company also is building barge docking and loading facilities on the Tombigbee River adjacent to the McIntosh plant. These will be in operation by late summer of this year and will permit shipments by water from the plant to river destinations, the Gulf of Mexico and beyond.

Beckman Instruments, Inc., has sent **William T. Gray,** service manager for its Spinco division, to Europe to establish a Spinco service center in Munich.

Establishment of the center within the facilities of Beckman Instruments, G.m.b.H., Beckman's wholly-owned subsidiary in Munich, will enable Spinco to provide direct service to customers in western Europe.

During his five-week tour, Gray will visit Spinco installations in Germany, Belgium, Sweden, England, Italy and Austria.

Fischer & Porter Company manufacturing affiliates and engineering representatives from 12 European countries will meet together for the first time on June 22. The meeting will be held at Otic-Fischer, Clermont-Ferrand, France.

Louis H. Aricson, vice president of the International division, will conduct the

ESCO

VALVES AND FITTINGS CAST IN ALL

CORROSION and HEAT RESISTANT ALLOYS

are designed to your specifications and your analyses . . .

You no longer need to let alloy problems or unusual shapes or sizes of fittings or valves limit the design of your piping systems.

ESCO can supply you with fittings and valves cast in all standard, or specially modified, corrosion and heat resistant alloys in wall section and dimensions to meet your most exacting requirements.

ESCO Alloy 45, with full 3% molybdenum content for digester circulating systems for sulfite mills (acid base liquors); *ESCO Alloy 40,* for digester circulating systems for sulfate mills (alkaline base liquors); *Alloy 20* and *Hastelloy Alloys B & C,* for other more severe corrosive conditions, are just a few examples of alloy availability. Monel, Inconel, pure nickel, Ni-Resist, 18-8 grades with .03 max. carbon and others are also available.

You get fast delivery—even on small quantities. No waiting for long runs of standard production items to be completed before your job can be started. Big orders can be handled efficiently and economically, too.

ESCO also offers you centrifugally-cast Spuncast® pipe, all types of flanges screwed fittings and flanged fittings cast specifically to meet your needs and analyses.

Complete engineering and metallurgical service is available when needed. Ask for details or write for free booklets "How to Cut Costs With *ESCO* Spuncast"..."*ESCO* Cast High Alloy Welding Fittings"."*ESCO* Stainless and High Alloy Products for the Process Industries."

...the toughest corrosion problems wind up at...

ESCO

HIGH ALLOY DIVISION

ELECTRIC STEEL FOUNDRY CO.

Manufacturing Plants
2164 N.W. 25th Ave.
Portland 10, Oregon
1017 Griggs Street
Danville, Illinois

ESCO International and New York Office
420 Lexington Ave., New York City, N.Y.

Other Offices and Warehouses
Los Angeles, San Francisco, Calif.
Seattle, Spokane, Wash.
Centralia, Pa.
Houston, Texas
Eugene, Ore.
Salt Lake City, Utah
Honolulu, Hawaii

In Canada, Vancouver, British Columbia and Toronto, Ontario.

For more data on advertised products, use Readers' Service Cards, last page.

STRONG is the word for Centrifugally Cast Pipe

. . . and the alloying is selected so that you will get high resistance to corrosion or high resistance to extreme heat or high resistance to both, as you require.

Centrifugally Cast Pipe has been a major DURALOY item since 1933 when we pioneered such high alloy castings in this country. Standard pipe production is in the following classification:

Outside Diameter	Minimum Wall	Length
2½" to 3"	1/4"	88" maximum
3" to 6" Inclusive	5/16"	110" maximum
Over 6" to 12" Inclusive	3/8"	168" maximum, 24" minimum
Over 12" to 14" Inclusive	7/16"	168" maximum, 24" minimum
Over 14" to 20" Inclusive	1/2"	180" maximum, 48" minimum
Over 20" to 24" Inclusive	1/2"	88" maximum
Over 24" to 32" Inclusive	5/8"	80" maximum

RESISTANT is the word for Chrome-Nickel Alloying

The strength of Centrifugally Cast Pipe comes largely from the exceptionally uniform dense grain structure.

If you require a gas or liquid pipe line or a process tube requirement calling for high strength plus high resistance to corrosion and/or temperatures in the piping, DURALOY Centrifugally Cast Pipe will meet your specifications with complete satisfaction. This is the record of our castings in industry for many, many years.

THE DURALOY COMPANY
OFFICE AND PLANT: Scottdale, Pa.
EASTERN OFFICE: 12 East 41st Street, New York 17, N. Y.
DETROIT OFFICE: 23906 Woodward Avenue, Pleasant Ridge, Mich.
CHICAGO OFFICE: 332 South Michigan Avenue

Suppliers . . .

meeting which will cover mutual manufacturing, engineering, and sales problems.

Otic-Fischer is Fischer & Porter's first European affiliate, having been established in 1947. Other European manufacturing affiliates who will attend the meeting include Solway Flowrators, Ltd., London, England; Fischer-van Winkel N. V., The Hague, Netherlands; and Sartorius-Fischer, Goettingen, Germany. Engineering representatives from Austria, Belgium, Denmark, Finland, Italy, Norway, Sweden and Switzerland will also attend.

Fischer & Porter Company has made three new promotions in its Sales department. **Philip E. Sellers,** formerly sales manager, becomes sales vice president; **Herman Kockritz,** formerly Southeastern divisional manager, becomes field sales manager, and **William Trethaway,** formerly sales engineer, becomes district manager of the Atlanta office.

General Electric Company has made **John S. MacDonald** general manager of its Distribution Assemblies department at Plainville, Conn. Manager of manufacturing operations service in G. E.'s Manufacturing Services since 1952, MacDonald replaces **Hershner Cross,** recently appointed manager of the Marketing Specialization Consulting Service. MacDonald has been with the company since 1931.

U. S. Steel Corporation has elected **Robert C. Tyson** to succeed **Enders M. Voohees** as chairman of the Finance committee, Voohees, who is retiring, will continue as a director of the company, consultant and member of the Finance committee.

Tyson has been with U. S. Steel since 1939. Most recently, he was serving as comptroller and vice chairman of the Finance committee.

The Lummus Company has appointed **Norman C. Kappler** as its pulp and paper industries consultant. He has been active in manufacturing, development and sales in the pulp and paper industry more than 30 years.

De Laval Steam Turbine Company has elected **Willis McDonald** a director. McDonald is a vice president of the New York Trust Company.

The Permutit Company has appointed **J. A. Meindl** as sales representative for Permutit Company of Canada, Ltd., in Toronto, Ont. Meindl has served as the Montreal sales representative for the past ten years. At the same time, **J. M. Watson** has been appointed to succeed Meindl as sales representative for the Montreal office.

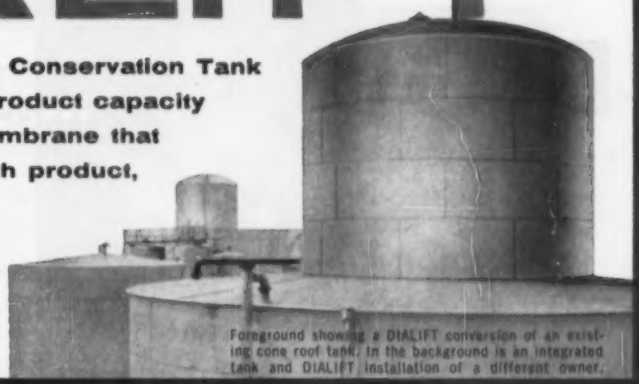
Cessna Aircraft Company has **William F. Quinby** as its new sales manager for the Central U. S. and Western Great Lakes region. He formerly was regional sales manager for Johns-Manville Sales Corporation at Houston.

Prior to his affiliation with Johns-Manville, Quinby was in the construction business in South Carolina and was a former captain for Corsairway, the airline

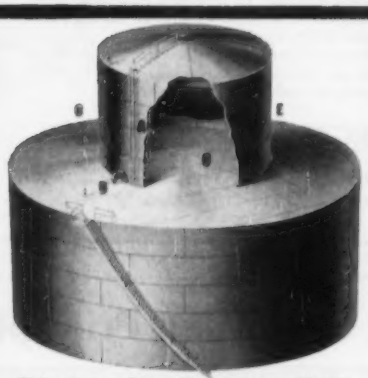
For more data on advertised products, use Readers' Service Cards, last page.

The HAMMOND
DIALIFT

The ONLY membrane type Conservation Tank with full-rated vapor and product capacity AT ALL TIMES, with a membrane that cannot come in contact with product, vapor space that can be isolated for inspection and maintenance without taking product storage tank out of service.



Foreground showing a DIALIFT conversion of an existing cone roof tank. In the background is an integrated tank and DIALIFT installation of a different owner.



Principle of the Hammond Dialift

- A— DIALIFT DIAPHRAGM rises and falls to accommodate expanding and contracting vapor.
- B— Vapor passes to and from tank and DIALIFT through simple elbow connection.
- C— DIALIFT and tank have full-rated capacity.
- D— Membrane can't come in contact with product.
- E— DIALIFT can be isolated for maintenance and inspection, product tank stays in service.

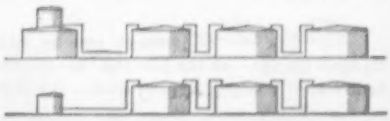
The most efficient and economical vapor conservation system for new or old tanks.

THE HAMMOND DIALIFT consists of a gas-tight Vulcalock membrane attached to the inside periphery of a cylindrical metal housing to become a "breathing" apparatus to accommodate the expanding and contracting vapor as developed in product storage tanks. The DIALIFT can be used as a single conservation unit by being attached to the roof of a product storage tank or as a central "breathing" system by being manifolded to a number of product storage tanks. There are two forms of installation: —Ground type manifolded to a number of tanks to form a conservation system and integrated type whereby the DIALIFT is attached to the roof of a product tank for vapor conservation for one or a number of tanks.

The DIALIFT is completely isolated from the product storage tank. Vapor passes between the tank and DIALIFT through a vaporline connection. It is easy to convert old cone roof tanks to efficient vapor-saving DIALIFT installations by attaching a DIALIFT housing with membrane to the roof of the old tank and connecting the vaporline between the tank and DIALIFT.

New or converted DIALIFT tank, inter-connected with cone-roof tanks, becomes central "breathing" unit.

DIALIFT GROUND UNIT serves as central "breathing" apparatus of multi-tank conservation system.



THE HAMMOND DIALIFT ELIMINATES BREATHING LOSS AND REDUCES FILLING LOSS

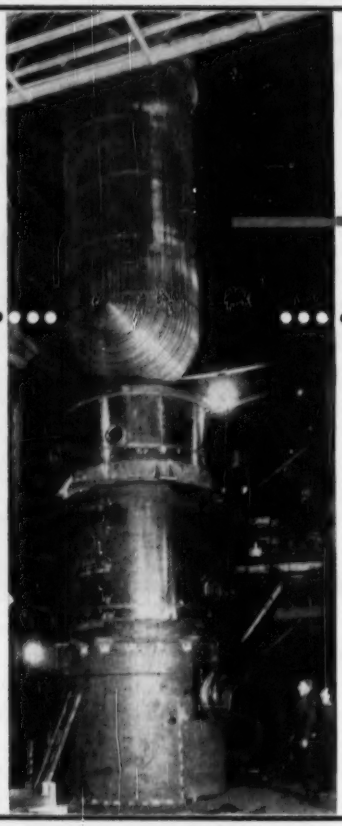
Write for catalog 55DL

HAMMOND IRON WORKS

WARREN and BRISTOL, PA. • PROVO, UTAH • CASPER, WYO. • BIRMINGHAM, ALA.

Sales Offices: NEW YORK 20 • AKRON • BOSTON 10 • BUFFALO 2 • CHICAGO 3 • CINCINNATI 2 • CLEVELAND 15 • EL PASO • HOUSTON 2 • LOS ANGELES 14 • PITTSBURGH 19 RICHMOND 20 • SAN FRANCISCO • WASHINGTON 6, D.C. • HAVANA • "TIPSA" BUENOS AIRES

BIG.....



ALBERGER
HEAT EXCHANGE EQUIPMENT

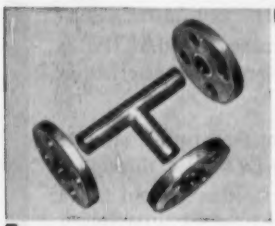
.....BIG *in design*
in manufacture
in performance

In the 52 years Alberger has been in business, it has made more than 40,000 installations of heat exchange equipment for process industries in the United States and in countries throughout the world.

The massive vapor condenser, shown here being assembled, is an example of Alberger's outstanding ability. Built for the National Aniline Division of Allied Chemical & Dye Corp., the condenser's Herculoy shell weighed 12 tons and its 25-ton tube bundle contained 12¼ miles of copper tubing carefully bent into 2150 U-tubes.

In all Alberger Heat Exchangers, heating surfaces are scientifically arranged to *increase heat transfer* and compactly assembled to *save space.*

ALBERGER HEATER DIVISION
ADSCO INDUSTRIES, INC.
20 MILBURN ST. BUFFALO 12, N. Y.

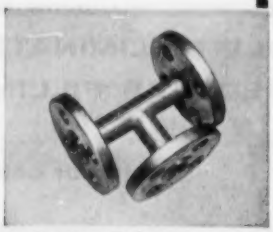


Speedline Tee and Speedline Insert Flanges before assembly.

HERE'S HOW...

Speedline fittings can be converted to flanged fittings—on the job. The "tangential" feature (additional straight section) makes the difference.

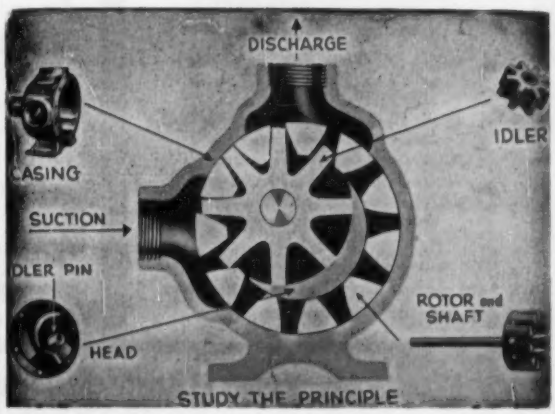
Speedline Tee with Flanges expanded on all outlets.



Write for YOUR Speedline Fittings Catalog *Today*.
Distributors are located in principal cities from coast to coast

Speedline® STAINLESS STEEL FITTINGS
manufactured by **HORACE T. POTTS COMPANY**
566 East Erie Avenue • Philadelphia 34, Pa.

Viking Operating Principle



Above are illustrated the major parts of the Viking Pump—casing, head, rotor and idler, separately and assembled. Imagine the rotor and idler in motion operating in a counterclockwise direction. Follow the course of the liquid from point of suction to point of discharge. Reverse direction will operate equally well. We invite your inquiries.

DISTRIBUTORS
SOUTHERN ENGINE & PUMP COMPANY
MANUFACTURERS • MACHINERY FACTORS • CONTRACTORS
Houston - Dallas - Kilgore - San Antonio - Edinburg
Corpus Christi and Beaumont, Texas.

Suppliers . . .

division of Consolidated Vultee Aircraft Corporation. He piloted four-engine transports on Corsairway's Trans-Pacific Airline.

Quinby also served with the Teleregister Corporation of New York as a development engineer and was the inventor of the dial-ticker communications system for the Toronto Stock Exchange.

General Electric Company has scheduled a $1,200,000 expansion and modernization program for its Small Turbine and Supercharger department.

Plans call for the erection of a new high pressure boiler plant. The plant, which will produce steam for the testing of the department's products, will contain a 60,000-pound-per-hour boiler and superheater with an initial steam output of 1800 psig at 1050 F.

Two nine-foot deep test pits are included in the new construction program. A $200,000 10-foot vertical boring mill will be added to the production line, as well as other smaller machine tools.

Burgess Manning Company has elected **Allen Wilson** as a vice president and **Dudley W. Day** as a member of the board. Wilson is manager of the company's Architectural Products division in Chicago; Day, who also is a vice president, is manager of the Penn Instruments division in Philadelphia.

Wilson had a long career in the acoustical business before joining Burgess-Manning Company two years ago. He was named manager of the Architectural Products division a year ago.

Day has been with the 12-year-old company since its inception and recently was named manager of the Penn Instruments division.

Beckman Instruments, Inc., has promoted three executives in its Helipot division.

D. C. McNeely becomes assistant division manager in addition to his duties as sales manager; Harry Schmidt will be production line sales manager of rotating equipment, and George Meadows has been named production line sales manager of volt meters and voltage regulators.

Fischer & Porter Company has formed a new Instrument division, completing its divisional decentralization program. The company is now divided into five product divisions—Flowmeter, Instrument, Chlorinator & Municipal, Glass, and Data Reduction & Automation.

The newly-formed Instrument division will be headed by **Donald J. Tricebock,** formerly assistant to the sales manager. The division will have complete responsibility over development, engineering, production, and sales instrumentation equipment for all process variables.

Tricebock joined Fischer & Porter in 1952 as electronics research engineer. Previously, he had been an electronic design engineer for RCA Victor.

Jones & Laughlin Supply Division has made two major promotions in its district sales organization.

J. K. Guinn, formerly general salesman at Oklahoma City, has been named district sales manager of the Central and Southern Oklahoma district, with offices

PACIFIC®

The name to remember when your problem is to start the charge stock and to keep it and its fractions moving without interruption on their guided tour through your process unit.

PACIFIC PROCESS PUMPS INSURE MORE SERVICE FOR YOU AND LESS SERVICING BY YOU

because

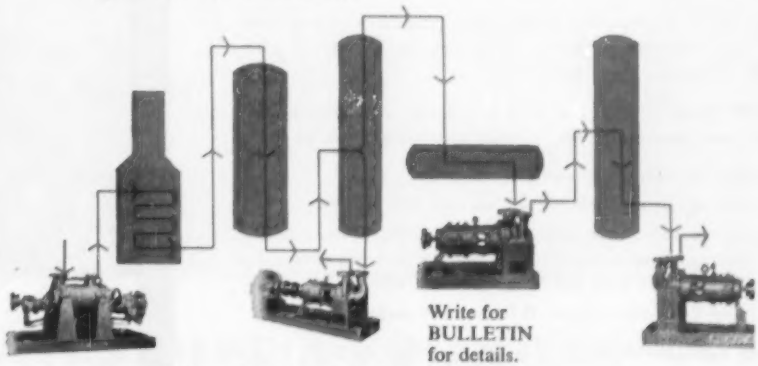
1. ***Design proportions are not limited*** to "just enough."
Extra heavy metal sections, identical bolting for glands and seal plates are combined with selected materials of construction to provide that "extra margin" needed to extend use life in corrosive-erosive services.

2. ***Guided inlet flow*** reduces prerotation and friction losses ... insures minimum required NPSH.

3. ***They are balanced—dynamically—radially—axially—eliminates—*** vibration that would cause damage to rings ... bushings ... bearings ... packing or mechanical shaft seals ... excessive radial and thrust loads on bearings.
Increases—availability for profitable operation.
Decreases—down time for maintenance.

4. ***Positive lubrication of bearings***—oil rings pump oil up into bearing cap from where it must flow through—not around—the bearings back into the oil reservoir—contributes to trouble free operation ... longer bearing life ... low maintenance.

5. ***Labyrinth seal*** in each bearing cap ... no contact between shaft and seal ... keeps oil in and dirt out of bearings—prevents contamination of lube oil—contributes to trouble free operation—low maintenance.



Write for BULLETIN for details.

Custom Designed, Engineered and Manufactured by:

PACIFIC PUMPS INC.

One of the Dresser Industries

HUNTINGTON PARK, CALIFORNIA

Offices in all Principal Cities

CP-13

For more data on advertised products, use Readers' Service Cards, last page.

U.S.P. PATENTED STAINLESS STEEL PROCESS M

Centrifugally cast stainless steel pipe passes rigid specifications . . . including severe hydrostatic pressure test.

The men who design today's petrochemical plants, refineries or Atomic power plants are confronted with piping problems involving temperatures, pressures and corrosive conditions which only a few years ago would have been called impractical, if not impossible.

U. S. Pipe's Steel & Tubes Division recently completed a piping requirement for 700 feet of Type 316 Extra Low Carbon, columbium-bearing stainless for a large petrochemical plant, which is typical of the job metal mold centrifugally cast pipe is doing today under a patented manufacturing process with rigid Quality Control.

U. S. Pipe is headquarters for metal mold centrifugally cast alloy and stainless steel pressure pipe over a wide range of special and standard analyses — in large or small quantities.

Write and outline your refining problems. We may be able to help.

Note these exacting specifications on 316 Cb ELC Stainless Steel Pipe demanded by one of nation's leading oil companies:

Material Requirements: Pipe shall conform to ASTM Specification A-362-52T.

Chemical Analysis: Modified AISI Type 316 Cb (ELC), with *one percent* spread on chrome and nickel.

Finish: Each pipe to be turned, bored and faced to surface finish of 125 micro inch or better. O.D. tolerance plus 1/16" minus 0"; I.D. tolerance plus 0" minus 1/32".

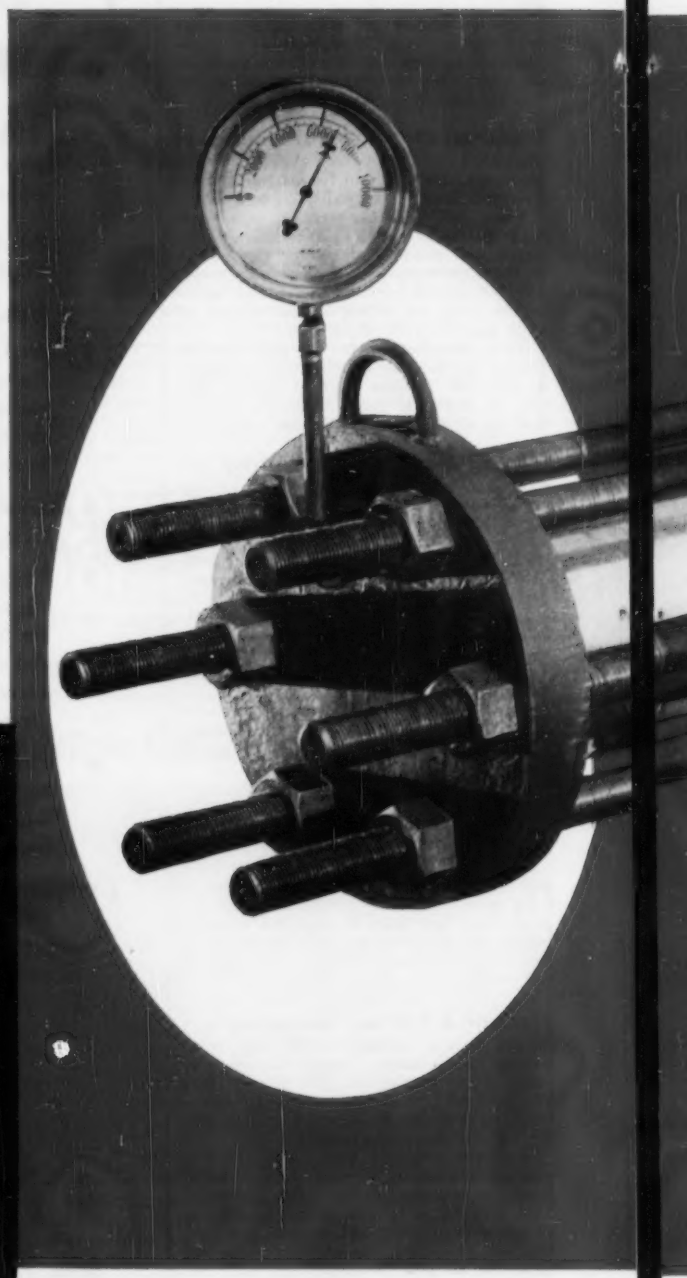
Mechanical Tests: Tensile Tests—2 tests required on each pipe after heat treatment; one at room temperature, one at 700° F.

Inspection Requirements;

1. Etching test on sections cut from each end of pipe.
2. Radiographic Inspection — Required complete circumferential coverage of at least an 8" wide section at each end of each pipe in accordance with ASTM Specification E71-52.
3. Fluid Penetrant — Entire O.D. and I.D. surface each piece.

Heat Treatment: Heat for 4 hours at 2100° F.—2150° F., water quench, follow by 5 hours at 1500° F.—1600° F. Cool in still air.

Hydrostatic Test: Each length tested to stress of either 90% of the minimum cold yield strength or a maximum pressure of 6800 psi — whichever is lower.



UPPER: Hydrostatic test rig used to qualify each length of pipe.

LOWER: Turned and bored stainless pipe is dimensionally accurate and furnished with superior I.D. surfaces.

MEETS RIGID PIPING REQUIREMENTS

UNITED STATES PIPE & FOUNDRY CO.

Steel and Tubes Division

STEEL AND TUBES DIVISION U S P

BURLINGTON, NEW JERSEY

SALES OFFICES: LOS ANGELES, SAN FRANCISCO, CHICAGO, ST. LOUIS, COLUMBUS, DETROIT, PITTSBURGH, HARTFORD, BURLINGTON

Suppliers . . .

in Oklahoma City. He succeeds **L. R. Roberts** who retired after nearly 28 years with Jones & Laughlin Supply Division.

In the West Texas district, **Glen A. Whiteker** has been appointed assistant district sales manager to supervise the western section of the district out of Odessa, Texas, and **H. H. Ray**, assistant district sales manager based in Abilene, Texas, has been assigned specifically in charge of the eastern section. F. L. McFarland, Midland, Texas, is district sales manager of the West Texas district.

U. S. Rubber Company has appointed **Bernhard Larsen** rubber-chemicals and synthetic-rubber technical representative for the Naugatuck Chemical division. He replaces **E. H. Nahm**, who retired after 29 years of service.

For the past year Mr. Larsen has been a rubber chemicals and synthetic rubber technical service representative for Naugatuck Chemical in Akron. He joined the company's Research and Development department in 1950, and in 1955 was assigned to Akron. He had previously been in development and production posts for three other rubber companies.

Nahm joined Naugatuck Chemical in 1927 and was immediately assigned to the Akron area to sell rubber chemicals. He was previously with the R & H Chemical Company, and prior to that he was factory manager for Ideal Tire and Rubber Company.

Air Products, Inc., has been appointed sole agent in the U. S. for the products of International Electrolytic Plant Company, Ltd., of Sandycroft, Chester, England. Air Products will market and service the British concern's electrolytic cells and related equipment.

Union Asbestos & Rubber Company has named **William H. Fehrs** as manager of sales for its Hand Brake division. Fehrs, who is a vice president and secretary of the company, had been assistant director of sales.

He joined the company in 1928 after nine years in the Mechanical Engineering department of Union Pacific Railroad.

Two years later, he was made assistant to the vice president of the company's Automotive division, subsequently becoming the division's sales manager.

Later, he served as plant manager of the Cicero factory, and, in 1944, was made assistant to the president in charge of railroad sales, a position he held for four years when he became vice president in charge of railroad sales. He was elected secretary in 1955.

U. S. Steel Corporation will have to expand its capacity by an average of one million tons a year for the next ten years, Board Chairman Roger M. Blough reported at the corporation's annual meeting of stockholders.

"Before we can even talk about expansion, however, we must first arrange to keep our present facilities intact," Blough declared. "We must replace those that wear out and modernize those that become obsolete. And this, today, is our most difficult problem. This is where inflation has hurt us the most."

Because present depreciation law permits an enterprise to recover only the original cost of facilities—not the inflated cost of replacing them—Blough urged "a prompt and realistic revision" by Congress of depreciation statutes. He asserted that such a revision "is already long overdue."

Roots-Connersville Blower, one of the Dresser Industries, is establishing a sales office in Pittsburgh. Heading up the new office will be **Edward N. Bonnett,** who will be responsible for the Pittsburgh territory which includes western Pennsylvania and the northern part of West Virginia.

American Cyanamid Company has **Frederick J. Edwards** as assistant advertising manager of its Industrial Chemicals division. He also will serve as advertising manager of the company's Paper Chemicals department and the Refinery Chemicals department. He formerly was a staff executive of the American Association of Advertising Agencies.

The Fluor Corporation, Ltd., has appointed supervisors of advertising, public relations and employee relations.

William R. Walker, former public relations representative, was named public relations supervisor.

Walter E. Terry was appointed supervisor of advertising and **Robert L. Wheeler** became supervisor of employee relations.

J. D. DeMarais will become supervisor of employee relations at Fluor's Mid Continent division in Houston.

Supervision of Fluor Products Company advertising remains under **E. B. Dewey.**

Jack McKay, manager of advertising and sales promotion, is leaving the company.

Babcock & Wilcox Company has started production at a new nuclear-facilities plant near Lynchburg, Va.

The plant is the first major facility in the nation erected entirely at private expense to manufacture and test nuclear fuel elements and related products for peacetime use.

The new plant is divided into two spheres of activity—a nuclear fuel element fabrication unit, and an experimental unit where reactor core components will be studied and tested.

The fabrication building, covering 32,000 square feet, has complete metal casting, rolling, welding and machining equipment to turn out flat-plate type fuel elements.

Elliott Company has made two promotions in its Crocker-Wheeler motor division. **Philip Scarola** has been named sales manager, and **Charles R. Steen,** manager of engineering.

Scarola, who was formerly manager of D-C application engineering, joined the company in 1942 as a field service engineer. From 1948 to 1954, he was a sales engineer in the Pittsburgh District Office.

Steen joined Elliott Company in 1954 as manager of D-C engineering after many years of association with the electric motor industry.

Worthington Corporation has made several promotions in the Engineering department.

E. C. Schmachtenberg, formerly assistant to the manager of engineering and chief engineer, compressors, has been named assistant to the manager of engineering. **Hunt Davis,** formerly chief en-

LITHIUM METAL AND ALLOYS
LITHIUM HYDRIDE
LITHIUM HYDROXIDE
LITHIUM CARBONATE
LITHIUM CHLORIDE - BRINE - etc.

LITHIUM
MAYWOOD

Pioneers in Lithium
Since 1901

MAYWOOD CHEMICAL WORKS
MAYWOOD, NEW JERSEY
ESTABLISHED 1895

Suppliers . . .

gineer, compressor development, has been appointed to succeed Schmachtenberg.

C. A. Macaluso, previously assistant manager, research and development, has been named assistant chief engineer, compressors. **W. F. Donovan,** formerly group supervisor in research and development, is appointed as his successor.

General Electric Company has a $23-million expansion and modernization program scheduled, covering the next five years, in its Medium Steam Turbine, Generator and Gear department.

Rhodia, Inc., has appointed Klenzade Products Company, Beloit, Wisc., as sales and service representative for its industrial reodorants in the central states. Klenzade specializes in pollution-control chemicals for many industrial operations.

J. F. Pritchard and Company of California has appointed **A. Gonzalez-Flores** as its sales representative in Mexico.

Gonzalez-Flores' experience includes working with refined sugar manufacturer and with Celanese Mexicana, S. A. He has been engaged in technical sales, development and engineering since 1951, specializing in vegetable oils, fats, soap and glycerine.

The Foxboro Company has appointed six new application engineers to sales-promotion posts at its home office in Foxboro, Mass.

Heading activities of the Chemical Industries Sales division is **V. A. Pardo,** transferring from Foxboro's Philadelphia branch office where he worked closely with leading chemical processors on instrumentation problems.

Also moved to the chemical group is **J. M. Petrillo** who has served in the Company's Metals Industries division since 1949. Replacing Petrillo is **R. C. Tamm,** formerly a design engineer with Wicks Boiler Company and Boston Woven Hose & Rubber Company.

Appointed manager of the Refinery Industries Sales division is **E. N. Hayes** who moves to his new assignment from Houston where he served as a Foxboro sales engineer. Hayes formerly was associated with Phillips Petroleum Company as a refinery process engineer.

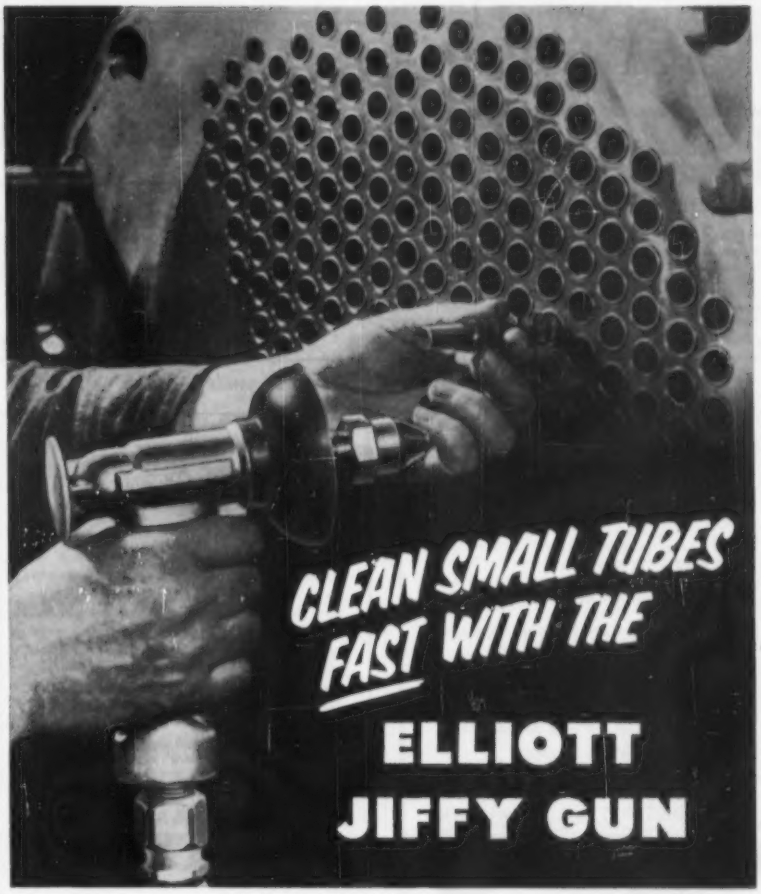
New members of the Company, **C. R. Fleming** and **J. W. Peirce,** have been assigned to the Power and Metals Industries Sales divisions, respectively.

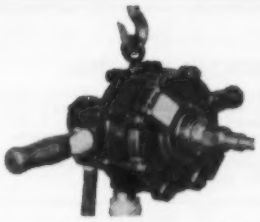
Hercules Powder Company is marking its 25th year of research and development at the central research laboratories near Wilmington, Del.

The research center today employs approximately 750 men and women. Most of the staff are specialists and technicians, and almost 300 of them professional scientists and engineers. In 1931, there were 125 employes, most of whom were transferred from Hercules' laboratories at Kenvil, N. J., established in 1915.

The company's expenditures for research at the time of opening of the experiment station were about $450,000 annually. At the present time, the rate is almost $8 million annually for the Hercules research program.

(More Suppliers, Page 300)

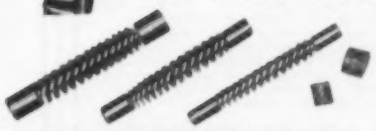




SUSPENSION CLEANER
For hard scale in straight tubes —direct drive cleaner using shaft and drill heads. Air or electric motor driven. Motor supported by overhead pipe.

JIFFY GUN BOOSTER
Combines water and air pressure for extra power and speed, recommended where water pressure is low, or scale deposit is heavy.

600 SERIES CLEANERS
For small curved or straight tubes. Air or steam driven motors. Can be equipped with brushes or scraper head.



JIFFY GUN BRUSHES AND PLUGS
Spiral-wound nylon brushes with rubber bumpers are favorites for small tube cleaning. Rubber plugs can also be used. Brushes and plugs available in required sizes.

For descriptive bulletins, write Elliott Company, Lagonda Division, Springfield, Ohio.

YG-3A **ELLIOTT Company**

STEAM TURBINES • MOTORS • GENERATORS • DEAERATING HEATERS • EJECTORS • CONDENSERS • CENTRIFUGAL COMPRESSORS • TURBOCHARGERS • TUBE CLEANERS • STRAINERS

For more data on advertised products, use Readers' Service Cards, last page.

PETROLEUM REFINER Classified Ads

Petroleum Refiner New Classified Rates

RATES: Regular Classified (undisplayed) set in this size type: 12 cents per word. Minimum charge, $3. Blind box address in our care counts six words. Replies forwarded without charge. Situation wanted ads, 6 cents per word. Display ads, set in suitably larger type with ruled border, $12 per column inch; situations wanted display ads, $6 per column inch. Ten percent discount for two or more insertions of same copy in consecutive issues. **All Classified ads payable in advance.** Copy deadline: 25th of month preceding date of issue. Send copy and checks to: Classified Advertising, Petroleum Refiner, P. O. Box 2608, Houston, Texas.

* * * * * * * * * * * * * * * * *

FOR SALE

New Fractionating Tower

One (1) new fractionating tower, 5'0" I.D. x 89'8" overall height x 1⅛" plate. Thirty-four (34) bubble trays, ten (10) 18" - 300# manways. Stress relieved and built in accordance with API-ASME Code for 350 PSI working pressure. Located Wichita, Kansas.

Rock Island Oil & Refining Co., Inc.
321 West Douglas Avenue
Wichita, Kansas

WANTED TO BUY

■ PETROLEUM REFINER Magazine back issues (also forerunner: Refiner) Wanted to buy for cash. P. R. Ashley, 27 E. 21 St., New York City (10), New York.

HELP WANTED

AREA ENGINEERS

Several graduate engineers with minimum 5 years' experience supervising maintenance engineering functions in oil refining or producing facilities, power plants, heavy industrial installations, manufacturing plants, or related operations. To establish technical supervision, procedures, maintenance operations and schedule routine and special work for major oil producing and refining operation with all supporting facilities; i.e., housing, feeding, recreation, etc.

Salary commensurate with background and experience. Write giving full particulars regarding personal history and work experience. Please include telephone number.

Recruiting Supervisor, Box 85

ARABIAN AMERICAN OIL COMPANY
505 PARK AVENUE
NEW YORK 22, NEW YORK

HELP WANTED

Plant Equipment Inspectors

Graduate engineers with minimum 5 years' experience in design or inspection of petroleum processing plants and equipment. Major part of experience must have been in inspection work entailing general knowledge of all facilities. Develop inspection methods, supervise and conduct inspections and advise operations on codes and equipment limitations in a major oil installation located in Saudi Arabia.

Write giving full particulars regarding personal history and work experience. Please include your telephone number.

Recruiting Supervisor, Box 91

ARABIAN AMERICAN OIL COMPANY
505 PARK AVENUE
NEW YORK 22, NEW YORK

PROCESS ENGINEER

"Experienced Engineers for process design with well established manufacturer, Mid-continent area. Challenging work with excellent opportunity for advancement. All replies will be kept in strictest confidence." Box 231-R, PETROLEUM REFINER, Houston, Texas.

PETROLEUM REFINING SPECIALIST

Position open in refinery technology division which carries out fuel evaluations, refinery studies, and other technical service projects for petroleum refiners. Required BS or MS degree in chemical engineering and 2 to 5 years of engineering experience in refinery operations—cracking, reforming, light ends, blending, economic analysis. Position offers opportunity for individual expression and responsibility and contact with persons in outside companies. Ideal location in suburban Detroit offers wide choice of living conditions.

Send resume of qualifications to:

Ethyl Corporation Research Laboratories
1600 West Eight Mile Road
Ferndale 20, Detroit, Michigan
Attention: Personnel Manager

PROCESS ENGINEERS

Upper Midwest Refinery has openings for Chemical Engineers with up to Five years experience in process engineering, economics or operational engineering.

Please include complete resume of experience, education, salary expected and references with reply.

INTERNATIONAL REFINERIES, INC.
Personnel Department
Box No. 8, Wrenshall, Minnesota

HELP WANTED

DESIGN ENGINEERS
DESIGN DRAFTSMEN

If you are interested in:

- **HIGHEST EARNINGS**
- **OVERTIME WORK**
- **PERMANENT EMPLOYMENT**
- **ADVANCEMENT OPPORTUNITIES**
- **IDEAL WORKING CONDITIONS**
- **WELL-LIGHTED, AIR-CONDITIONED OFFICES**
- **MANY OTHER BENEFITS**

Please be sure to contact or see

ARTHUR G. McKEE & CO.

With Engineering Offices in
CLEVELAND, OHIO and UNION, NEW JERSEY

McKee is a 50-year-old Engineering and Construction firm doing business on a world-wide basis.

We have interesting, well-paying positions for

DESIGNERS & ENGINEERS

qualified in

Piping	**Pressure Vessels**
Concrete	**Equipment Specs.**
Structural	**Architectural**
Electrical	**Mechanical**

DESIGN DRAFTSMEN AND DRAFTSMEN

qualified in:

PIPING	**STRUCTURAL**
CONCRETE	**ELECTRICAL**
	ARCHITECTURAL

Refinery, Chemical, Blast Furnace, Steel and Sintering Plant, Industrial or Office Building design or drafting experience desirable but not necessary.

The expanding McKee organization, with three engineering divisions, Refinery, Metals and Industrial, offers many interesting opportunities in these highly-paid fields.

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Permanent responsible positions with opportunity for high calibre men in Engineering Department of large Gulf Coast chemical manufacturing plant. Applicants should have the following qualifications:

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5. Ability to work with others in a team.

Positions are in Process Design Section for work on new plants and additions to existing plants. Work includes translation of pilot plant processes into full scale plant design, design calculations on distillation, heat transfer, mass transfer, fluid flow, and associated work necessary to prepare flow sheets (no drafting). Processes are both organic and inorganic. Some field data and production equipment performance evaluation involved. Small electronic computer to be available in this work. Assignments will allow for full recognition of individual's ability, with commensurate salary.

Replies held in strictest confidence, all will be answered. Please send complete resume, including education, experience, and salary expected to Mr. D. M. Duguid, Technical Employment Manager.

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Above with 3 to 7 years' experience in Refinery or Process Chemical Plant.

JUNIOR ENGINEER
Prefer B.S.M.E. with some metallurgical training, experience or interest

Please send resume and salary requirement to Industrial Relations Department Head

GRACE CHEMICAL COMPANY
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. . . As a result, we have an immediate need for an outstanding Engineer with at least 5 years experience in process design and facilities planning. Position of Facilities Specialist will involve design and layout of the silicone plant of the future. Can be excellent opportunity for advancement to Manager or Consultant. High starting salary.

Please send resume to

BOX 236-R,

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■ LUBOIL PLANT Wanted second hand in good condition with Vacuum Dest., Solvent Extraction, MEK Dewaxing, Continuous Treating and Barrel Filling. Intake Capacity 1000 bbl/day. Send bids to Box 237-R, PETROLEUM REFINER, Houston, Texas.

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Reply Box 234-R,
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■ Academic position open. Instructor or assistant professor starting September 1956 to teach Chemical Engineering and subjects related to Petroleum. Position permanent. Salary and rank depend upon qualifications. Write to Dean of Faculty, Colorado School of Mines, Golden, Colorado.

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■ Chemical Engineer with experience in gas plant operation, development and process engineering, employed, desires position with advancement potential in gas or petrochemical industry. Box 223-R, PETROLEUM REFINER, Houston, Texas.

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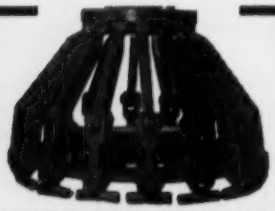
Suppliers . . .

Emsco Manufacturing Company has **Jack E. Human** as part of its sales force. He will devote his time to the sale of swivel joints as well as joining in the sales effort of the company's Structural and Galvanizing departments. Before joining Emsco, he was with Associated Piping and Equipment Company for five years.



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Fisher Governor Company has appointed J. G. Chilcoat and Company, a Pittsburgh concern, as its exclusive sales representative for western Pennsylvania and West Virginia.

The new sales office is headed by **Jess G. Chilcoat**, who has been associated with Fisher Governor Company both in field offices and at the Marshalltown plant more than ten years. **S. W. Prince, R. G. Read** and **Bob Neville**, all formerly with the W. A. Stoeltzing Company, Pittsburgh, will be associated with Chilcoat as sales engineers.

The Dow Chemical Company will build a new administration center at its plant in Midland, Mich. The center in its final form will be a group of three buildings in an area almost a half-mile long and a quarter-mile wide, containing headquarters for the entire company.

The plan calls for construction of the first three units of the center as soon as plans have been finalized and bids taken.

The unit to be built first is the Chemical Sales and Technical Service building, which is expected to be completed late in 1957. This unit will be substantially larger than the present company Administration building. The latter now provides office space for more than 1000 employes.

The next units to be built are an Executive Office building, which will be the heart of the center, and a Plastics building.

The Executive Office building will house the company officers, staff departments, general services, and cafeteria. The Plastics building will be headquarters for the plastics management and staff, Plastic Sales, Coatings Technical Service, Plastics Technical Service, and related groups.

The Chemical Sales and Technical Service building will house the General Chemicals management; the Organic, Inorganic, Dowicide, Alkali, Solvents and Agricultural Chemicals sales departments; the Technical Service and Development department, including sections of it now quartered in Bay City; the company's Traffic department; and related service groups.

Air Reduction Company, after 26 years at the same New York address, has moved into the new Socony Mobil building. The company's address will be 150 East 42nd Street, New York 17. It will occupy the third and fourth floors of the skyscraper which is the world's largest fully air-conditioned building.

ALCO Products, Inc., has made three new assignments in the Personnel department at its Dunkirk, N. Y., plant.

Under the reorganization, **Henry Gdula** will be plant personnel manager; **Robert Webster** will assume community relations responsibilities, and **Kenneth C. Brimmer** will be supervisor of employment and placement practices.

American Meter Company, Inc., has named **Robert R. Troyer** as assistant to the advertising manager.

U. S. Steel Corporation has appointed **Jay R. Stewart** as controller of its U. S. Steel Products division.

He began his business career with Weirton Steel Company in 1931 and joined U. S. Steel in 1943 as a member of the audit staff of Carnegie-Illinois Steel Corporation.

A year later he advanced to assistant works auditor at Homestead Works, Munhall, Pa., and in 1951, was appointed works auditor at Duquesne Works, Duquesne, Pa. In 1953, he returned to Homestead as works auditor at the pioneer U. S. Steel plant, the position he held prior to his present appointment.

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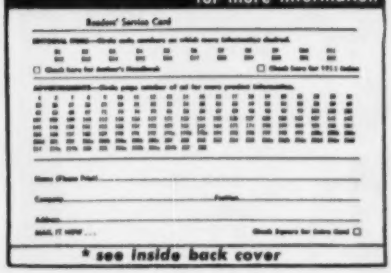

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New ways of doing many shop jobs that have improved results in other plants;

A wealth of practical helps, ranging all the way from how to start a diesel engine, or preparing boilers for inspection, to winding springs, or remedying leather belting troubles.

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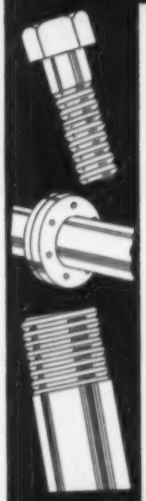

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What's New in Equipment . . .

. . . and Manufacturers Literature

Automatic Switches . . . A new 16-page factual brochure in color "Factors to Consider in the Selection of Automatic Transfer Switches" (Publication 596) simplifies specification of this equipment.

The features required for adequate design are listed—then information is given on why these features are essential. Factors considered include:

1. Capacity to withstand inrush currents.
2. Continuous duty rating.
3. Ability to transfer load rapidly.
4. High thermal capacity.
5. The need for easy inspection and maintenance.

Additional information includes "Selection of Type," "How to Specify the Switch Capacity," "Calculating Line Currents" and "A Suggested Specification for Automatic Transfer Switches." Automatic Switch Company.

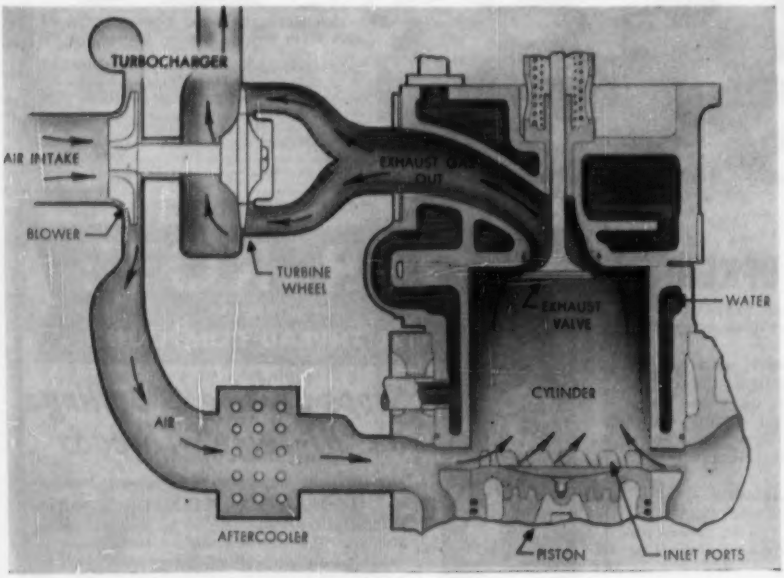
Circle Item E1 on the Card.

Dehumidifiers . . . Answers to a number of dehumidification questions are given in this information Bulletin 496. Also shown is equipment used in removing excess moisture from the air and instruments for measuring humidity. Control of comfort conditions and prevention of rust, mold, mildew and corrosion are described. Abbeon Supply Company.

Circle Item E2 on the Card.

Explosion-Proof Switches . . . Micro explosion-proof switches are designed for use as limits, safeties and interlocks in explosive atmospheres. Underwriters Laboratories list these switches as suitable for hazardous locations of Class I, Group C and D and Class II, Group E, F, and G. Applications and details of construction are included in Catalog 83a. Micro Switch, Minneapolis-Honeywell Regulator Company.

Circle Item E3 on the Card.



New compressor available in 750 to 2500 HP range.

No External Mechanical Drive Required for New Turbocharger

Turbocharger Compressor . . . A new gas-engine compressor, known as the SUTC Turbo-Uniflo, is now available in the 750 to 2500 horsepower range. This is the only two-cycle spark-ignition gas-engine compressor that operates with a completely independent exhaust gas-driven turbocharger.

Operating at relatively high compression ratio, this unit has smooth combustion characteristics. This is due to the basic timing arrangement, engine configuration, and design of exhaust manifolding. The new design results in quieter operation, low fuel and lube oil consumption, and low BMEP—96.1 psi at rated speed and load. A complete absence of residual gases in the combustion chamber results in high turbocharging-scavenge ratio.

The new compressor is designed for pipeline transmission service; in natural gasoline plants; for refinery operations such as vapor recovery, re-cycling and stabilization of gases; for refrigeration systems; and for use in the petrochemical industry where various processes require the use of natural gas under pressure. Worthington Corporation.

Circle Item E4 on the Card.

Plastic Insulated Motors . . . A new line of "Linc-Weld" motors are available in standard sizes from 1 to 40 horsepower. They are said to be the first in this size range with extruded plastic insulation.

The plastic, in extensive field tests, has demonstrated exceptional resistance to chemical action, humidity, abrasive dust, lint, and oil vapors. In applications that formerly required a totally-enclosed frame, this motor has performed much longer than the one it replaced. In addition to chemical protection, the insulation provides thermal protection. "Hot spots," confined inside areas of motors that do not receive ventilation, are eliminated. The plastic provides a medium for conducting the heat uniformly away from every wire.

These motors are built in the open type frame and torque design B. They comply with NEMA specifications. Lincoln Electric Company.

Circle Item E5 on the Card.

Linear Amplifier . . . Bulletin 71 describes features of a new non-overloading linear amplifier. The new instrument, designated the RLI-1, was developed to meet the need for a high gain linear amplifier with excellent overload characteristics.

The voltage pulses obtained from almost all nuclear radiation detectors necessitate some measure of amplification to make them large enough in amplitude to be usable. Where pulse height analysis is to be performed, it is necessary that the amplifier be able to introduce a minimum of distortion into the relative size and shape of the output pulse, that is, it must be linear.

Under many circumstances, it is also essential that the signals be unaffected by the presence of large numbers of signals many times the amplitude which would be necessary to drive the amplifier to full output. Thus, the amplifier must be non-overloading.

The new linear amplifier has a gain of 8,000 and a pulse rise time of 0.25 microseconds. Output noise is less than 1 volt peak-to-peak when the amplifier is operating at maximum gain settings. In addition to good linearity (better than 1 percent)

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MOTOR STARTERS
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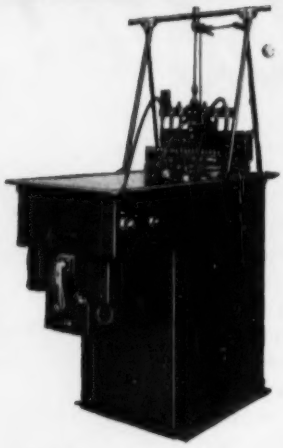
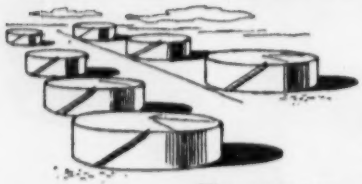


Contactor and Relay Panel are bolted together for raising as a unit above the oil. No leads or bolts to disconnect. Shown is Cat. No. 2645A Lifting Mechanism, available at small cost.

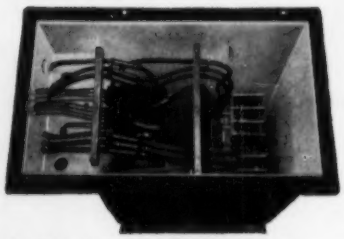


These starters are designed specifically for Division 2, semi-hazardous locations. They are low in first cost and are easy to service when inspection or maintenance are necessary. They require little floor space.

High interrupting capacity is inherent . . . 50,000 KVA and no power fuses required. The well-known Type ZHS Magnetic Contactor has been certified for this rating. It is of heavy-duty construction to assure trouble-free operation.

Before buying 2300-5000 volt motor starters, investigate EC&M Type ZHS Starters. They provide economy in installation, operation and maintenance, and are available in a range of horsepower sizes.

Write for Bulletin 1062-20.



Looking down into starter showing anti-syphon lead construction from contactor, control transformer and overload relay panel to conduit connection box with threaded couplings. Starter with oil disconnect switch shown in views above.

6886-EC&M

THE ELECTRIC CONTROLLER & MFG. CO.
Division of Square D Company
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New Equipment . . .

and high signal output level (to 120 volts), the amplifier has excellent overload characteristics. When subjected to a one microsecond input signal whose amplitude is 100 times that necessary to drive the amplifier to full output, no ringing double pulsing or baseline shift is observed. Tracerlab, Inc.

Circle Item E6 on the Card.

Electrolytic Hygrometer . . . Bulletin 484 describes an electrolytic hygrometer capable of measuring one part of water in a million parts of air. The new hygrometer is based on a du Pont design. It automatically and continuously measures water content of very low ranges in gas samples —an important factor in many applications for controlling corrosion, product purity and process efficiency. An extensive evaluation program of the many potential applications for this hygrometer is now underway. Beckman Instruments, Inc.

Circle Item E7 on the Card.

The Dew Point Story . . . The terms "dew point, relative humidity, and saturation point," are explained in non-technical language in this six-page reprint booklet.

Written by P. M. Hankison, president of the company, the booklet describes the workings of a typical plant compressed air system and offers an analogy to explain such terms as dew point, etc. The booklet also explains how moisture vapor in compressed air may be eliminated through dew point. Hankison Corporation.

Circle Item E8 on the Card.

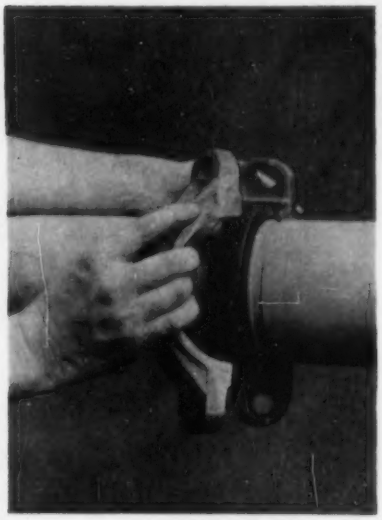
Metallic Bellows Pump . . . Improved metering pump for pressures to 2500 psi and flow rates as low as 5 cc per hour is described in Bulletin 300. Actual pumping element is a metallic bellows—hermatically sealed. Hydraulic fluid expands bellows to give positive displacement of fluid.

There is no contact of chemical fluid with any frictional moving parts in the

New Equipment . . .

reagent head. All components of the liquid end are of corrosion resistant alloy. The entire reagent head may be removed and replaced with another self-contained spare assembly. There is no stuffing box or packing. This feature reduces maintenance and leakage. Hills-McCanna Company.

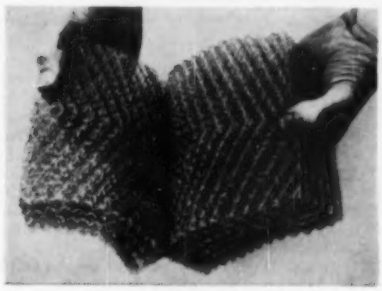
Circle Item E9 on the Card.



Grooved Pipe Couplings . . . Now accepted for listing by Underwriters Laboratories, Inc., these couplings for grooved pipe are available in seven sizes from 2 inches through 8 inches.

Savings up to 50 percent are claimed for installations on tank batteries, tanks, manifolds and related equipment. With "Gruvajoint" couplings, flanging, threading or welding are unnecessary. Nor are chain tongs or pipe wrenches needed. "Rolagrip" couplings are available for plain end pipe. Gustin-Bacon Manufacturing Company.

Circle Item E10 on the Card.



Mesh Mist Eliminator . . . A new type of wire mesh entrainment separator, knitted from Monel nickel-copper alloy wire for use in corrosive environments has been developed. The wires are repositioned by a herring-bone fold to expose greater area for impingement. The improved mesh is said to be more economical in drying gaseous streams and more efficient in preventing valuable or troublesome products from going up the stack.

Monel wire eliminators have been found

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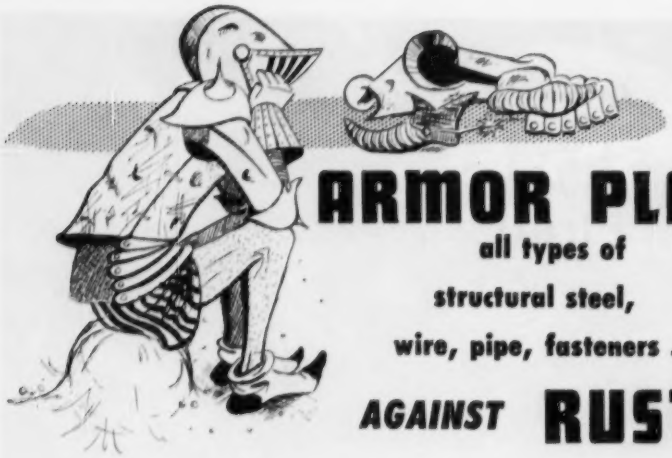


ARMOR PLATE

all types of

structural steel,

wire, pipe, fasteners . .

AGAINST **RUST!**

The Nowery J. Smith Company can give our rusty friend's iron tuxedo a tough zinc coating to seal out corrosion even while dragon-slaying or maiden-rescuing! Whether your galvanizing job is routine—or singular as a suit of armor—call the Nowery J. Smith Co., UNderwood 9-1425, for the best in hot-dip galvanizing service.

one of the SMITH Engineered Services for Southwest

Nowery J. Smith COMPANY

Hempstead Hwy. at Eureka Underpass Phone UN 9-1425
HOUSTON, TEXAS

a MERE GLANCE gives the FASTEST CHECK of ORIFICE PLATES when you install the NEW

CLAYTON MARK & COMPANY

TABBED ORIFICE UNIONS

SIZES 1¼" THRU 3"

● To speed-up the checking of Orifice Hole Sizes the extending tab (an integral part of the Orifice Plate) is permanently stamped with hole size for quick and easy reading.

● Plates are positioned to maintain correct alignment of the Orifice Hole.

● 18-8 Stainless Steel Plate and double jacketed Asbestos Gaskets held firmly in a solid steel groove facilitate tightening and guard against blowing of gaskets and resultant trouble. These Unions, recommended for flow control on all services up to 3000 pounds C.W.P., are forged of Carbon or Stainless Steel in Screwed and Socket-Weld types.

All CLAYTON MARK Union Products, plus a complete line of FORGED STEEL and ALLOY FITTINGS are available at your local supply store.

MAIL THIS COUPON TODAY!
PLEASE SEND US COMPLETE INFORMATION ON THE TABBED ORIFICE UNION
NAME_____
ADDRESS_____ CITY_____ ZONE_____ STATE_____
CLAYTON MARK & COMPANY • 1900 Dempster Street • Evanston, Illinois

New Equipment . . .

very durable in caustic soda evaporators and when exposed to hydrogen sulfide in refinery gases below 500 F. Eliminators made of Monel alloy wire have been used in a variety of equipment in chemical plants and petroleum refineries where droplets of sulfuric acid may be entrained. The new separator units have one-half to one-third the pressure drop of the older type, and purge themselves more readily. Metal Textile Corporation.

Circle Item E11 on the Card.

Drum Upender . . . Less muscle is needed to upend loaded oil or chemical drums using the newly developed Morse drum upender No. 32. The new drum upender has a 40-inch handle, offset 35 degrees for maximum efficiency in raising drums from horizontal to vertical. A 1¼-inch hook provides adequate clearance for the largest chime. A 2½-inch x 8-inch toe plate spreads lifting pressure over a large area to prevent drum damage.

This new tool, engineered for manually upending heavy drums with a minimum of effort speeds production, makes drum handling a fast, one-man operation. It cuts lost manhours due to personnel injuries while handling heavy drums. Strong and durable, the tool is designed to give long, economical service. Morse Manufacturing Co.

Circle Item E12 on the Card.

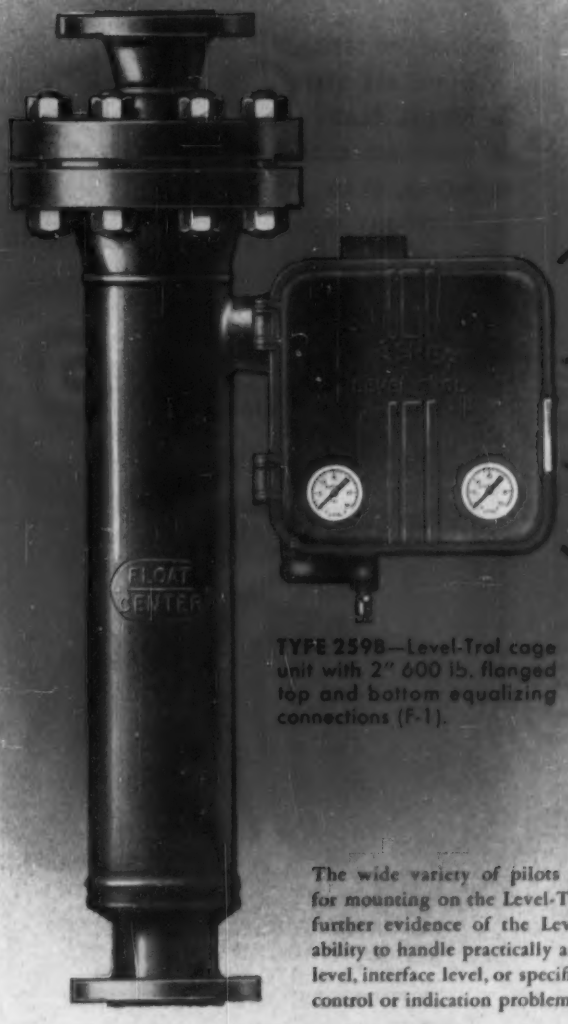
Corrosion Prevention . . . A new 20-page technical data booklet entitled *Sodium Nitrite for Rust and Corrosion Prevention* is available from Solvay Process Division. The booklet includes an indexed bibliography of 59 selected technical articles dealing with corrosion-inhibiting and prevention methods, procedure and materials. Solvay Process Division, Allied Chemical & Dye Corporation.

Circle Item E13 on the Card.

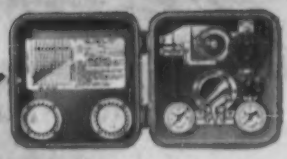
Gas Chromatography . . . A new instrument for gas and vapor phase chromatography is described in Kromo-Tog Booklet 83. Using the principle of elution with either liquid partition or solid absorbents, the Kromo-Tog Model K-2 provides the analyst with a complete and accurate breakdown of many different gas and liquid mixtures with a clear cut resolution of all components. Because it is extremely fast and easy to use, analyses heretofore requiring complex equipment

FISHER
LEVEL-TROL

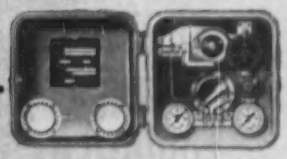
The Answer to Your Liquid Level Needs



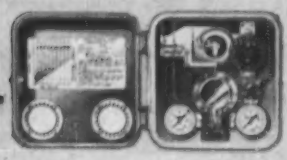
TYPE 2598—Level-Trol cage unit with 2" 600 lb. flanged top and bottom equalizing connections (F-1).



TYPE 2500—proportional pilot for general liquid level control applications.



TYPE 2500T — Level-Trol pilot used as pneumatic level transmitter.



TYPE 2500C—pilot with level indicator. Indicator available on all style Level-Trol pilots.

TYPE 2500 — 2516 dual Level-Trol pilot consisting of Type 2500 for remote level-indication or recording and Type 2516 controller with proportional and reset response.

The wide variety of pilots available for mounting on the Level-Trol gives further evidence of the Level-Trol's ability to handle practically any liquid level, interface level, or specific gravity control or indication problem.

FISHER GOVERNOR COMPANY

MARSHALLTOWN, IOWA • WOODSTOCK, ONTARIO

WORLD LEADER IN RESEARCH FOR BETTER PRESSURE AND LIQUID LEVEL CONTROL

FISHER *Since 1880*

For more data on advertised products, use Readers' Service Cards, last page.

NO.2 in a series of **ALUMICOAT APPLICATIONS**

RESISTS HIGH TEMPERATURE CORROSION!

Alumicoat

Molten Aluminum

PROCESS PROTECTS REFINERY EQUIPMENT

More and more refineries are discovering the advantages of the new ALUMICOAT Process! ALUMICOAT offers a firm resistance against corrosive media — *especially sulphur compounds* — and extreme temperatures!

In the ALUMICOAT Process, refinery parts are dipped in molten aluminum to produce a metallurgical iron-aluminum bond at the interface and a surface overlay of pure aluminum. At temperatures exceeding the melting point of aluminum, the aluminum on the surface diffuses. This diffused coating, together with the iron-aluminum bond, provides a refractory material that gives steel maximum protection against high temperature scaling.

The Alumicoat Process can solve your corrosion and oxidation problems. Send for full details today!

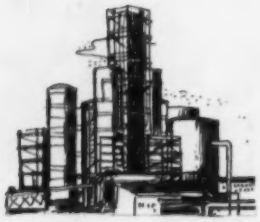
ARTHUR TICKLE ENGINEERING WORKS, INC.

26 Delevan Street MAin 5-4200 Brooklyn, N. Y.

POSEY LARGE O.D. PIPE

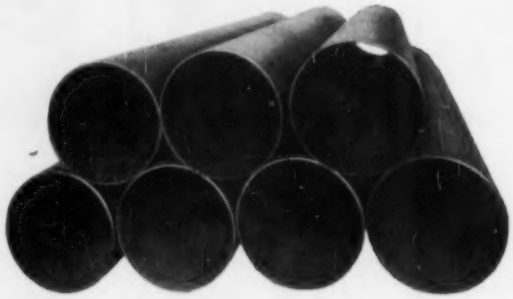
For Specialized Uses In Oil Refineries

- CARBON STEEL
- STAINLESS STEEL
- NICKEL CLAD
- STAINLESS CLAD
- MONEL CLAD
- WROUGHT IRON



Posey has the experience as well as the facilities for fabricating almost any type of pipe from 20" diameter and larger. You can trust Posey to meet your most rigid specifications . . . with special attention to budget and delivery requirements. Write for complete information without obligation.

Fabricated in accordance with ASTM Specifications, Class A252-46



ELEVATED TANKS • DIGESTERS
HORIZONTAL TANKS • STACKS
STEEL PLATE FABRICATION
DREDGE PIPE AND ACCESSORIES

POSEY IRON WORKS, INC.

Steel Plate Division - Lancaster, Pa.
New York Office: Graybar Building
Established 1910

New Equipment . . .

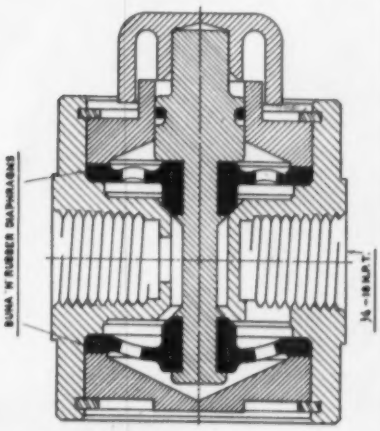
and taking hours to complete have been reduced to everyday laboratory routine.

The new instrument accommodates two columns for maximum flexibility and economy in use. Two identical or different samples may be in work at the same time, or one column may be conditioned and charged for reuse while the other column is analyzing. The columns may contain different adsorbents and be operated at different temperatures. Burrell Corporation.

Circle Item E14 on the Card.

Spray Lubrication . . . Graphite lubrication for both metallic and non-metallic surfaces is now available in this 6-ounce spray container. Instant drying, there is no surface build-up or drippage when applied. Oxidation, corrosion, and friction of moving parts are reduced and sticking prevented. The effective temperature range is from —100 F to 800 F. American Resin Corporation.

Circle Item E15 on the Card.

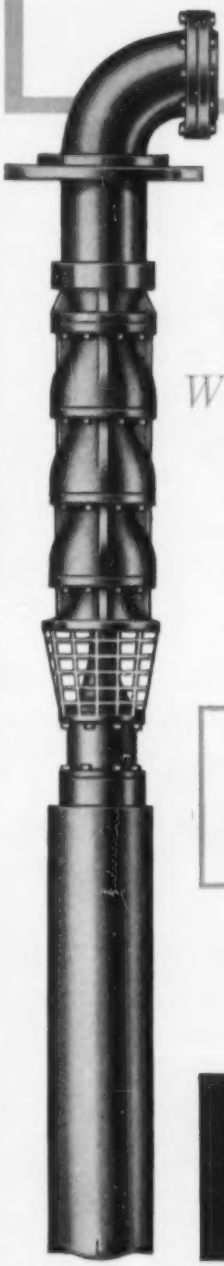


Quick-Dump Valves . . . A new line of flow control valves, said to incorporate a basic improvement in design, is described in this brochure. These valves are intended for use in original equipment as well as numerous applications in industry that require either manual or automatic valving of air, water, oil or freon.

The "Quick-Dump" line utilizes a single basic valve body which may be used either

Verti-Line *Submersible*

BOOSTER PUMPS



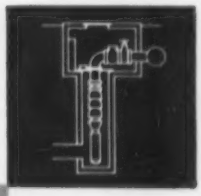
Layne & Bowler's half-a-century of experience in the design, engineering and manufacturing of vertical pumps, and the know-how of General Electric in the electric motor field *are now joined to produce the most advanced Submersible Booster Pumps made.* Sizes from 5 to 125 H.P.

Why Submersible Boosters?

For invisible, noiseless operation!
For safety—to people and equipment!
For dependability in any weather!
For maximum use of minimum space!
For maintenance-free performance, without adjustment or lubrication!

Some typical applications

pumping directly into distribution mains



fire protection

sump operation

cooling tower service

Send today for new bulletin containing description of pump and motor features, material specifications, selection tables and application data. Ask for bulletin T-66

Verti-Line Pumps are the exclusive products of
LAYNE & BOWLER PUMP COMPANY
general offices and main plant
2943 VAIL AVENUE • LOS ANGELES 22, CALIFORNIA

For more data on advertised products, use Readers' Service Cards, last page.

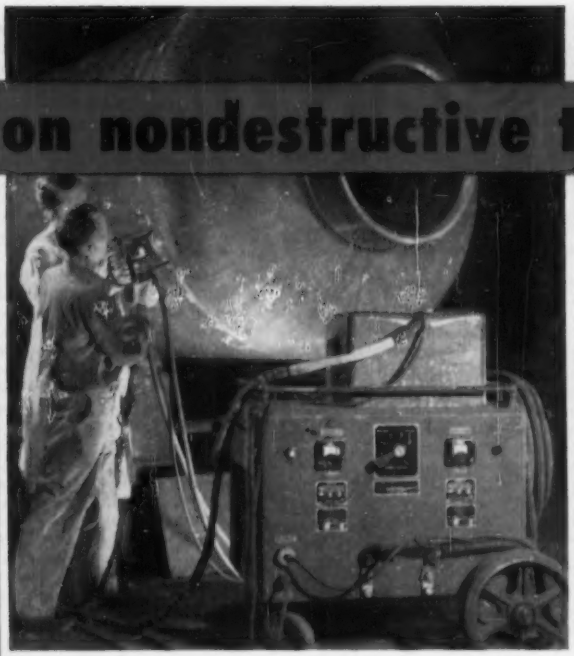
A. O. Smith reports

Radiography is perhaps the most important inspection method A. O. Smith uses to detect flaws in welds and adjacent base material. The products of A. O. Smith — such as steam water heaters and domestic storage tanks, to pressure vessels of various types — require radiography. Inspection of light gauge thickness and heavy wall thicknesses exceeding 6 inches. We make use of both x-ray and gamma-ray inspection and both methods record on film the density variables characteristic of unsound material. Technician is shown x-raying the longitudinal seam of an alloy-lined shell.

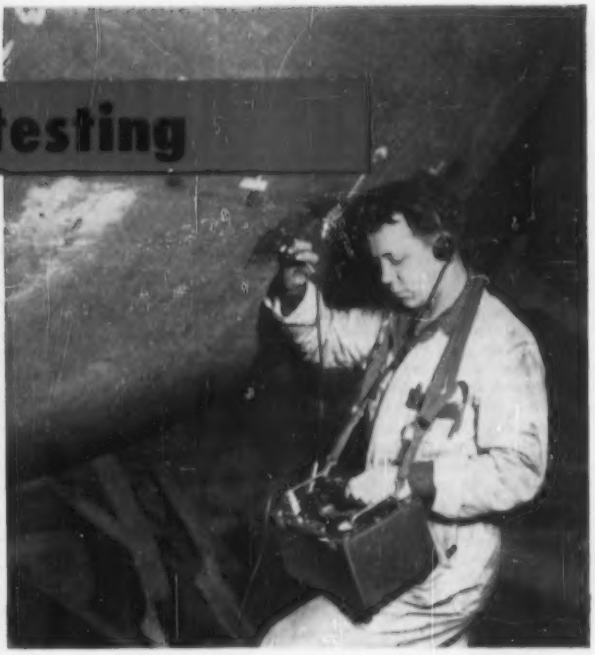
Skilled interpretation of the film is, of course, the key to successful radiographic inspection. If all the film developed and interpreted at A. O. Smith since 1932 were laid end to end, the strip would extend over 1,224 miles.

Important applications for nondestructive tests are those that determine acceptability of materials for specific corrosion-resistant or welding characteristics. Sulphur printing, illustrated here, is one of the control inspections used by A. O. Smith. The test is designed to determine the amount and segregation of sulphur present in forgings. This inspection evaluates the forging for welding.

on nondestructive testing



Still another method of flaw detection used by A. O. Smith is the magnetic particle test. Magnetic particle tests are ideal for detecting surface and sub-surface faults in ferrous materials. In this picture, technicians are shown inspecting the welds on a pressure vessel.



Ultrasonic testing (inspection utilizing high-speed sound waves) is another method A. O. Smith uses for quality control of heavy sections. The picture shows an additional application of ultrasonic testing — operator is determining wall thickness of 167,000-lb. vessel.

Nondestructive inspection is one more reason for the dependability of A. O. Smith vessels, exchangers and other process equipment.

The man in charge of A. O. Smith's nondestructive testing . . .

A. Cota. With A. O. Smith for more than 27 years, Mr. Cota has specialized in nondestructive testing since 1932. He has been a leading force in the development of many of the techniques and procedures now used throughout industry. He is past-president of the National Society for Nondestructive Testing . . . is serving on nondestructive testing committees of ASME and ASTM and in various other control groups. This experience is another reason why it's wise to call A. O. Smith first for processing equipment.

Illustrated here are just a few of the nondestructive testing processes by which A. O. Smith maintains the quality of its products. Of course, there are many other tests, too — both nondestructive and destructive — all designed to help create equipment that will excel in your operations.

A. O. Smith was one of the members of the original committee that first established radiographic inspection techniques and standards. Also, we have used magnetic particle testing since 1934 . . . ultrasonic testing procedures since 1945.

Through research . . . a better way

A.O.Smith

CORPORATION

PROCESS EQUIPMENT DIVISION

HEAT EXCHANGERS • PRESSURE VESSELS

Milwaukee 1, Wisconsin

International Division: Milwaukee 1, Wisconsin

New Equipment . . .

normally open or normally closed, depending upon port connections. To this standardized valve body may be added a variety of simple devices for triggering the valve action. Seven models are currently available—solenoid, cam-operated, palm button, finger-tip, foot-operated and two types with hand lever.

In this new valve, the manufacturer explains, the opening, closing and holding action are effected by the pressure of the air or liquid. Because the valving action works with the pressure instead of against it, it is claimed that all performance characteristics are enhanced. Valve action is triggered by a light touch. Shut-off is sure and positive. Cycling is ultra-rapid.

Construction of the valve is simple. There are no internal packings, springs, or pistons, no sliding of metal-to-metal contacts. Wear is said to be reduced to a minimum and service life is greatly prolonged. The valve body is machined from solid bar steel with corrosive resistant finish and is equipped with "Buna-N" rubber diaphragms. Valve is adapted for applications up to 125 psi and under temperature variations from —40 to 225 F.

The solenoid operated valve has several unique features. A momentary electric impulse triggers this valve to open or closed positions. No current is required to "hold" since there is no prolonged flow of current. Danger of overheating the coil is said to be eliminated, and solenoid life is lengthened. Humphrey Products, General Gas Light Company.

Circle Item E16 on the Card.

Fin-Fan Exchangers . . . An informative 24-page bulletin describing the latest developments in air-cooled heat exchangers has just been published.

Bulletin 2400 fully describes the design details, construction, distinctive features and applications of the Griscom-Russell air cooled unit known as the G-R fin-fan exchanger. Also included are specifications, sketches of available arrangements, and descriptions of mechanical equipment and control apparatus for various service requirements. Griscom-Russel Company.

Circle Item E17 on the Card.

V-Belts . . . A new bulletin describing Worthington-Goodyear V-belts is now available. Featured are steel cable belts which have the highest horsepower rating of any standard section V-belt. They are especially adaptable for drives requiring extra strength and heavy continuous service. High tensile airplane type steel cables carry the load. Worthington Corporation.

Circle Item E18 on the Card.

Insulation—Insulations and refractories for general industrial applications are described in new 20-page catalog. This is a factual type catalog organized for quick reference work. It provides information on the composition, physical and thermal properties and sizes of the various products. It lists outstanding benefits which the products provide both at the time of installation and in service. It covers materials for the efficient control of temperatures from 400 F below zero to 3000 F above. Johns-Manville.

Circle Item E19 on the Card.

Time Switch . . . A new general purpose time switch, featuring greater reliability at less cost than its predecessor, has been developed. Suitable for indoor and outdoor use, the new heavy duty TSA-40 (replacing the T27) will turn electric currents on or off at any time of day. It can be used to control all types of street, sign, store and flood lighting, capacitor switches, heating, air conditioning and refrigeration equipment, irrigation and pump devices, and many other types of apparatus where precise time control is necessary.

An outstanding feature of the new switch is the unique shearing action of the contacts which are forced to slide against each other as they open and close. This prevents welding and keeps contacts clean under heavy overload conditions. Unit construction of the terminal block and contacts eliminates internal wiring which helps prevent hot spots and burnouts.

Its 4-watt motor, with permanent silicone-grease lubricant sealed in, operates from —50 F to 150 F, making the timer adaptable for use under almost any climatic conditions. The sealed-in lubricant makes it possible to stock the switch for extended periods without danger of the motor becoming inoperative. General Electric Company.

Circle Item E20 on the Card.

Pipe and Tubing Stresses . . . Engineers associated with the design of equipment involving the use of tubing at elevated temperatures and pressures will be interested in a new technical data folder numbered TDC-154A.

This folder gives the maximum allowable stress values for ferrous pipe and

FREE TEST SAMPLE CAN shows how C-5 solves "HIGH-TEMP" THREAD PROBLEMS!

Prove it to your own satisfaction that C-5 ENDS STUD SEIZING AND GALLING EVEN AT 1800° F

Leading petroleum processors are now using C-5 for flange bolts, studs, and all other threaded surfaces on reactors, cat crackers, autoclaves, heating exchangers, catalytic reformers, pumps and valves, etc., and other applications where temperatures are up to 1800° F.

Fel-Pro's exclusive C-5 colloidal copper formula "copper-plates" metal . . . gives maximum cushioning and protection to 1800° F. without breakdown.

C-5 prevents galvanic action—eliminates pitting even where dissimilar metals are joined . . . protects all threaded surfaces, insuring their repeated re-use!

Write today for your FREE Test Sample CAN. Felt Products Mfg. Co., 1546 Carroll Ave., Chicago 7, Ill.

fel-pro C-5 "HIGH-TEMP"

√ Prevents Stud Breakage
√ Ends Stainless "Pitting"
√ Reduces Torque
√ Speeds Disassembly

1287

ANTI-SEIZE THREAD COMPOUND

PRESSURE VESSELS

FOR

PETRO-CHEMICAL PLANTS

You can use the wide experience of St. Mary Iron Works when you build pressure vessels. Our thoroughly experienced staff of designers, engineers and fabricators will furnish the equipment you need. Consult us before you start new construction.

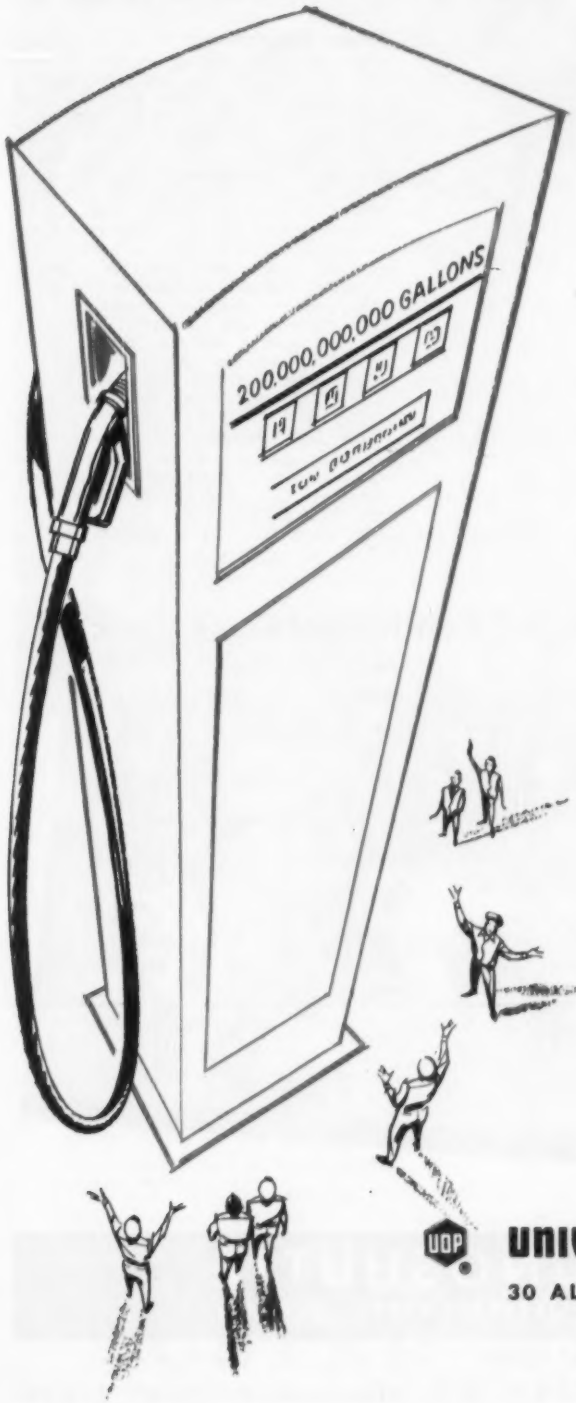
ST. MARY IRON WORKS

Steel Fabricators for Half a Century

FRANKLIN, LOUISIANA

More than 200,000,000,000 GALLONS

OF GASOLINE KEPT GUM-FREE WITH UOP #5 INHIBITOR



Any way you figure it, that's a lot of gasoline . . . convincing proof that the petroleum industry has approved and demanded UOP #5 Inhibitor.

Obviously, there are good, sound reasons for this preference. UOP #5 has demonstrated unexcelled inhibitor potency and versatility. It is the product you can depend on for the really tough stability jobs.

UOP #5 is economical. For any given stability requirement you can't beat #5 on a cents (or fraction thereof) per barrel basis. Remember, five molecules of UOP #5 will protect 1,000,000 molecules of gasoline.

UOP Inhibitor #5 was introduced by Universal during World War II and the techniques of applying it have been effectively developed over the years. This experience is offered to refiners, and our on-the-spot representative will be glad to assist in its application to your products. Just write us.

PRODUCTS DEPARTMENT

UNIVERSAL OIL PRODUCTS COMPANY

30 ALGONQUIN ROAD, DES PLAINES, ILLINOIS, U. S. A.

For more data on advertised products, use Readers' Service Cards, last page.

New Equipment . . .

tubing. Included are the values at various temperatures for a complete range of seamless and welded carbon, alloy and stainless tubing steels.

Also included are the formulas to be used in connection with the stress value in calculating the maximum allowable working pressures. Babcock & Wilcox.

Circle Item E21 on the Card.

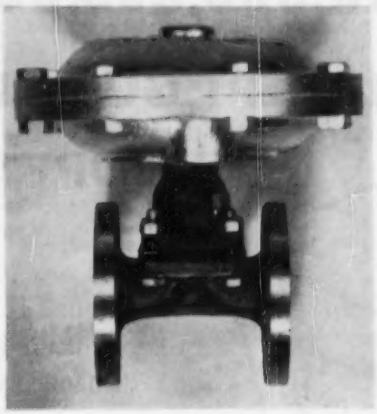
Hotter Plug . . . A new cold-headed electrode is the latest development for this unique radial cathode spark plug. Broader by 25 percent, this electrode shoots a full circle of fire to a flashpoint area of 360 degrees instead of the single lane sparking on conventional plugs. This results in a hotter, stronger spark. The wider area of contact also insures a permanently fixed gap which remains constant after thousands of car miles.

The complete combustion gets maximum energy from lean fuel mixtures, allows less back pressure in the exhaust systems and means longer life for costly engine parts. The radial cathode further acts as a baffle against carbon and oil deposits and protects the insulator from imperfect oil mixtures. Self-cleaning, the new plug is said to be unaffected by oil splash or water.

Preset at the factory for all makes and years of cars, these plugs need no adjusting before installation. They require no testing, checking or cleaning at tune-ups since no gap loss occurs. American Eagle Corporation.

Circle Item E22 on the Card.

Small Control Valve . . . A new small flow, air-operated control valve is now available for use in research laboratories, pilot plants and other industries that require corrosion resistant valves. Furnished with a springless motor in ½ and ¾ inch sizes, the overall height of the valve is only 6 inches. Bodies can be furnished screwed or flanged in these materials: cast iron, stainless steel, rubber lined, glass lined, Hastelloy "C" and many other materials.



These valves are said to be ideal for use in controlling very high vacuum. Top mounted valve positioners can be supplied for throttling control. Uniflow Valve Corporation.

Circle Item E23 on the Card.

New Compressor . . . A new engineering catalog, Bulletin F-80, describing the newest type FMP compressor is available on request. The new reciprocating compressor is built for field pick-up service, gas boosting, air drilling and general industrial use.

It is available with either single or twin frames, with single or multi-stage compressor cylinders. Ratings are up to 600 horsepower as belt-driven or completely packaged unit. Cooper-Bessemer Corporation.

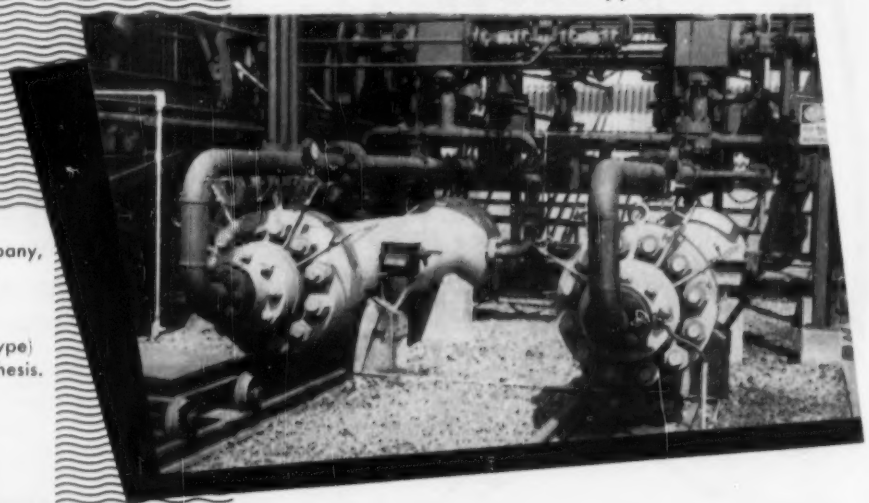
Circle Item E24 on the Card.

Steel Floor Armor—The uses of steel floor armor to prolong the life of floors are described in an illustrated booklet. This new brochure shows both the application and installation of Hexsteel heavy duty floor armor and Floorsteel flexible type floor armor through a number of simplified illustrations and engineering data. Hexsteel is a steel surface armor designed to take the brunt of rolling loads and to increase the life of industrial floors, ramps, docks and aisles. Floorsteel is a flexible floor armor used for armoring irregular surfaces. Included in this report are complete detailed specifications for both types of floor armor and instructions for determining the size armor which should be used for each specific installation. Klemp Metal Grating Corporation.

Circle Item E25 on the Card.

Fire Equipment—Various generally accepted methods of fire detection, fire prevention, fire control and fire extinguishment are covered in an illustrated bulletin entitled "Engineered Special Hazard Fire Protection." This booklet includes

GHH H.P. Centrifugal Gas Circulators,
Maulwurf-type

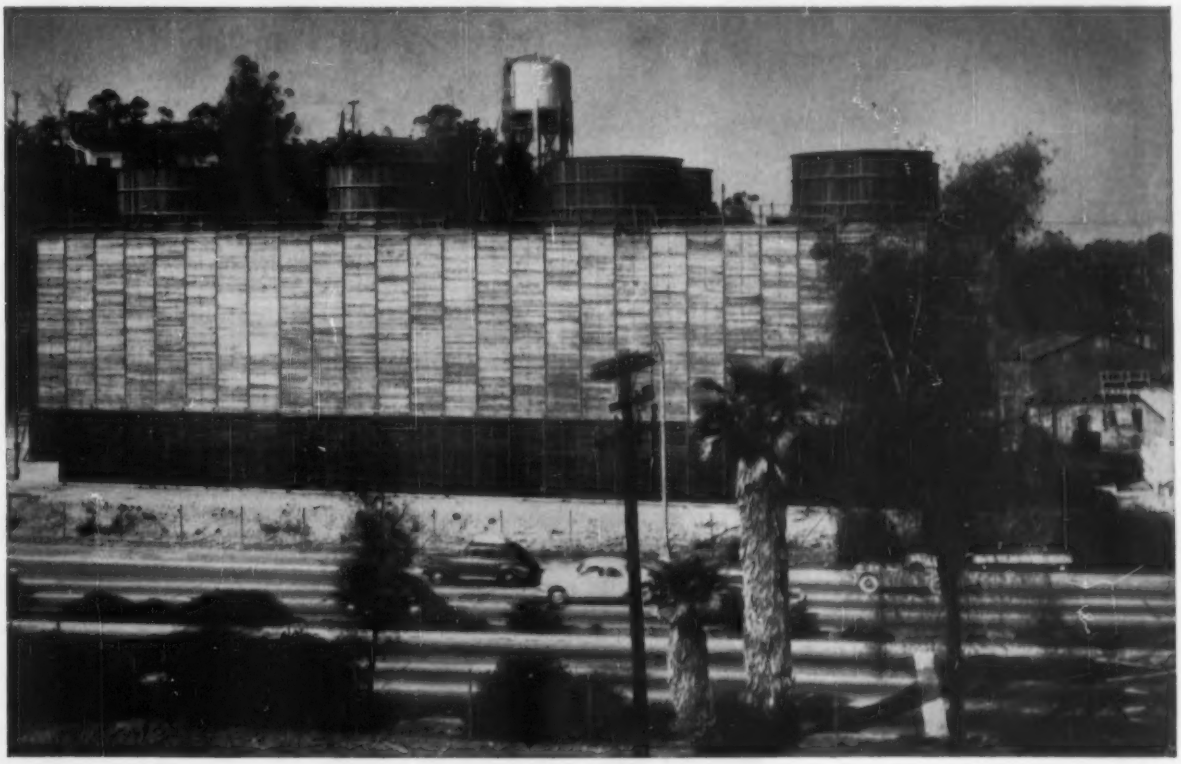


Spencer Chemical Company, Vicksburg, Mississippi, employs two GHH centrifugal gas circulators (Maulwurf-type) in their ammonia synthesis. These units have operated without trouble since February, 1954.

GUTEHOFFNUNGSHÜTTE
STERKRADE AKTIENGESELLSCHAFT · STERKRADE WORKS · GERMANY

REPRESENTATIVES: THE FORAM CORPORATION
15 MOORE STREET, NEW YORK 4, N.Y. Telephone: Whitehall 3-8241

COOLING TOWER
Eliminates Highway Fogging Problem



Careful Custom-Engineered Design eliminates driving hazard on one of Southern California's main traffic arteries

THE Municipal Light and Power Department of the City of Pasadena, California, faced a serious problem in locating cooling towers within 25 feet of the Arroyo Seco Freeway at their Broadway Steam Plant.

Although the vapors from a cooling tower contain nothing but pure water and do not *pollute* the atmosphere, "fogging" of the Freeway could not be tolerated as a driving hazard.

The Foster Wheeler eight-cell cooling tower shown above, installed in 1954, has successfully met this challenge. Freedom from "fogging" of the Freeway was achieved by proper drift-eliminator design, correctly engineered exit vapor velocities, and the use of *moderately* high fan stacks extending 12 ft. above the fan deck and 55 ft. above the basin curb.

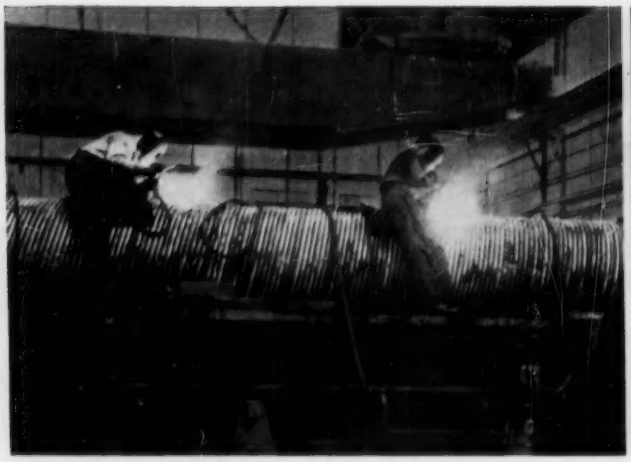
Complete satisfaction with this initial FW Cooling Tower has now been proved by the City's recent re-order of a duplicate FW Tower to be located down the property line adjacent to the Freeway.

THIS NEW BULLETIN describes the *new* Foster Wheeler induced-draft, counter-flow cooling tower — every detail designed for long-range dependability and economy. Send for your copy today. *Foster Wheeler Corporation, 165 Broadway, New York 6, N. Y.*

FOSTER WHEELER

NEW YORK • LONDON • PARIS • ST. CATHARINES, ONT.

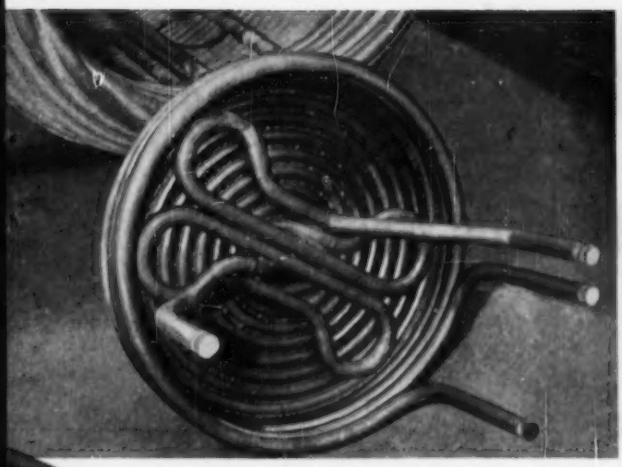
For more data on advertised products, use Readers' Service Cards, last page.



▲ In the fabrication of special combination reactor and heat exchanger, thousands of feet of tubing had to be precisely wound into a helix to form a baffle. The seam of the helix was completely welded inside and out.

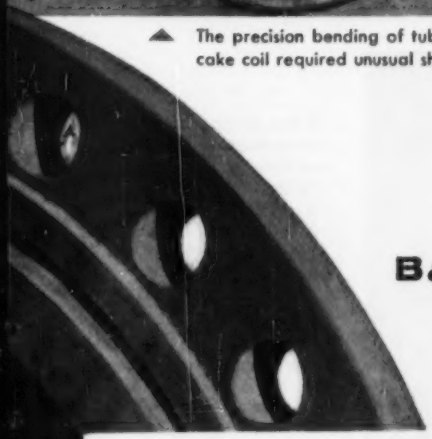
▲ B&W pioneered the development of pressure vessel welding. Here an experienced hand welder is working on alloy header protection plates.

▶ Measuring peep sight coils, which are located in manway of main drum.



▲ The precision bending of tubing to form this pancake coil required unusual shop skills.

▲ Manufacture of the header protection coil involved many special techniques in bending and welding.



B&W's *Engineering and Manufacturing Skills Produce Something New and Different In*

PRESSURE VESSELS...

Designing and manufacturing the equipment for a special combination reactor and heat exchanger for a petro-chemical plant required something unusual in the way of engineering and manufacturing skills. B&W design and manufacturing engineers contributed materially to the solution of these problems through their techniques, skills and depth of experience accumulated in producing thousands of pressure vessels, boilers, refractories, burners and tubing, of all types and for virtually every application.

The design and fabrication of this complex unit is but one example of how B&W blends engineering skills and unexcelled facilities—backing both with continuing research in many areas. Because B&W has long been meeting the special requirements of modern chemical, petroleum and steam generating operations, you will receive the ultimate in engineering and experienced craftsmanship when you bring your process equipment problems to B&W. The Babcock & Wilcox Company, Process Equipment Department, Barberton, Ohio.

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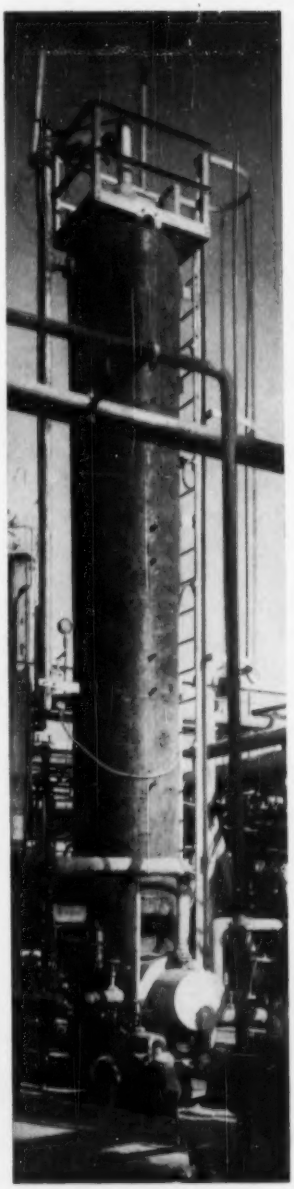
The Ridge Tool Company, Elyria, Ohio, U. S. A.

Now you get Double-action cleaning on Double-trouble jobs with OAKITE COMPOUND No. 85



Those tough soils built up on refinery equipment are doubly tough to clean – a solvent is needed for removing carbon deposits, and then an acidic cleaner for iron oxides and sulphides.

Now, with new Oakite Compound No. 85, you can do both jobs at the same time – remove carbon *and* iron oxides and sulphides in a single cleaning operation on absorbers, debutanizers, de-ethanizers, feed stock preheaters, heat exchangers, stabilizers. O.C. 85 gives you these extra advantages:

- Fast soil penetration
- Does not attack steel
- Long-lasting solutions
- Rinses freely
- Safer than raw acids

Ask your local Oakite Technical Service Representative to show you how Oakite Compound No. 85 can save you considerable off-stream time. Or write for Bulletin F3751 to Oakite Products, Inc., 48 Rector Street, New York 6, N.Y.

OAKITE

Export Division Cable Address: Oakite

New Equipment . . .

research, engineering, contracting, production, installation and inspection of special hazard fire control systems. Automatic Sprinkler Corporation of America.

Circle Item E26 on the Card.

Vibration-Proof Flow Alarm . . . The first flow alarm to combine low cost with vibration-proof operation has just been developed. Known as the F & P Ratolarm, it uses two snap-action electrical contacts, hermetically sealed in a glass tube, which are drawn together to set off the larm by passage of a magnetic float extension rod.

The switch can be positioned in the mounting frame either above or below the magnet in the float extension rod to give a signal for either high or low limits of flow. If placed above the magnet, it will set off the alarm when increasing flow causes the magnet to rise to a predetermined position. If placed below the magnet, it sets off the alarm when the flow falls below the desired rate or fails entirely. One switch can be set above and another below the magnet to give high and low alarms. Multiple alarms may be incorporated for special applications.

The Ratolarm will replace the mercury switch and inductance coil types formerly used on F & P instruments for flow alarm applications. Unlike the mercury switch, it is insensitive to vibration and can not give false alarms.

One of the most important applications for the flow alarm is in water or oil cooling lines for large machines. It may be connected to a light or buzzer or both, or may be used to start a pump, close a valve, shut down the system, or perform other on-off control functions. Fischer & Porter Company.

Circle Item E27 on the Card.

Variable Area Flowmeters . . . Recently introduced 1700 series, variable area Flowrator meters are described in a new 16-page catalog. The 1700 series is said to combine many features and proven principles of previous F & P Flowmeters plus added strength, corrosion-resistance, and versatility.

The catalog describes in detail the models available, various types of tubes and floats, predictable performance characteristics, construction features and accessory equipment. Fischer & Porter Company.

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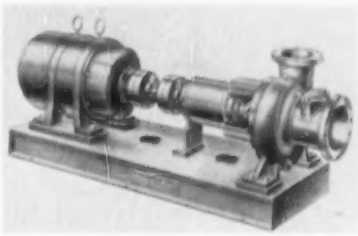


New Industrial Liquids Pump . . . A completely new centrifugal pump, said to be the first real departure from the conventional type of centrifugal pump, has been announced by Ingersoll-Rand Company.

Classed as a Paper Stock and Industrial Liquids Pump, it features a diverging type impeller which enables the pump to handle liquids containing high concentrations of solids, air and gases. This new pump is a horizontal, single-stage unit, built in sizes from 4 to 12 inches, with capacities from 200 to 7000 gpm and heads from 5 to 225 feet. Ingersoll Rand Company.

Circle Item E29 on the Card.

Instrument Air Regulator . . . Black, Sivalls & Bryson, Inc. has introduced its new type 73-26 instrument air regulator. The unit provides close regulation demanded for instrument air supply in pneumatic instrumentation.

The unit includes a micron phenolic impegnated cellulose filter. It has a minimum pressure drift from set point and gives instantaneous response to changes in flow rate.

The new regulator can be panel or bracket mounted and service without removal from the air line. It is available with or without auxiliary pressure gauges. Connection are ¼ inch pipe. Maximum input pressure is 300 psig. Maximum output pressure is 40 psig. 100 psig is available with a special spring. The body is of die case aluminum alloy with stainless and plated steel internals to provide a sturdy but light weight regulator. Black, Sivalls & Bryson, Inc.

Circle Item E30 on the Card.

Anhydrides . . . A new booklet (F-5280) on anhydrides has just been published. Anhydrides are extremely reactive chemical intermediates. They are used in the manufacture of textile fibers, plastics, pharmaceuticals, flavors and odorants.

This booklet gives suggested uses, physical properties, specifications, test methods, shipping data, and constant boiling mixtures for these anhydrides: acetic anhydride, propionic anhydride, and butyric anhydride. Carbon and Carbide Chemicals Company.

Circle Item E31 on the Card.

Nickel Pressure Vessels . . . Of interest to designers is a new 27-page technical booklet entitled "Nickel and High-Nickel Alloys for Pressure Vessels." This interpretive report reveals how nickel alloys can be correctly applied and economically used when their properties are known and suitable allowances are made.

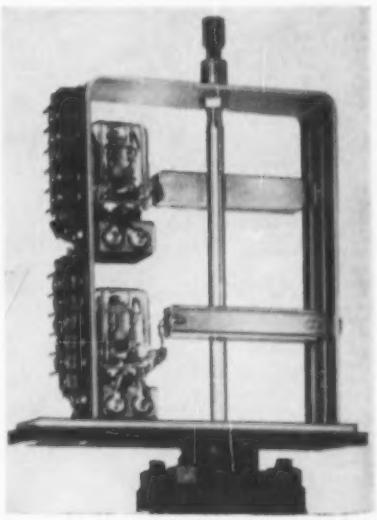
The nickel alloys have become increasingly important for pressure vessel work as modern industry turns to higher pressures and temperatures. These conditions tend to increase the problems of corrosion, high temperature strength, and metal stability as well as placing greater demands on the need for safeguarding product purity. The International Nickel Company.

Circle Item E32 on the Card.

Tube Selection Data . . A 44-page manual to assist engineers in the selection of condenser tube alloys has been published. This booklet, (No. B-2) discusses the application and installation of condenser and heat exchanger tubes, also plates for tube-sheets, heads and baffles.

The facts set forth are especially for engineers responsible for the selection of material in the marine, oil refinery and stationary steam power plant industries. Detailed information, based on actual installations as well as laboratory tests, is presented. The American Brass Company.

Circle Item E33 on the Card.



Vibration Monitor . . . This new multi-channel vibration monitor provides instantaneous warning when unbalance occurs, or when any bearing on a large rotating machine, or machine combination, begins to fail.

Explosion-proof electro magnetic pick-ups are mounted on each bearing housing, and are connected to the control unit. The vibration level at each bearing is measured with the channel sensitivity control, and the control is then set slightly above the normal existing vibration. An increase in roughness or vibration at any bearing actuates alarm contacts. If the vibration exceeds the set level by a ratio of four-to-one and persists for ten seconds, or a selected time interval, shutdown contacts are actuated.

Applications include centrifugal compressors, gas and steam turbines, diesel engines, generators and other large rotating equipment. The Beta Corporation.

Circle Item E34 on the Card.

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Rail Record for Length

• This Tower, 203 feet overall, left Wyatt's Houston Plant on six flat cars and set a new load record for length for the area's railway facilities.

The vessel, 13 feet inside diameter, weighs 435,000 pounds.

Wyatt's
HOUSTON-DALLAS-NEW YORK-TULSA

MANUFACTURERS AND ERECTORS SINCE 1913

Tested, proven durability

McDonald Swing Joints

practically no wear in 100,000 double revolutions

You'd expect the best from the originators of the Swing-Joint — and that's what you get with McDonald. Special tests conducted on our Master Swing Joint by a well-known research laboratory showed practically *no wear in more than 100,000 double revolutions of the ferrule.* McDonald design, based on a century's experience, gives you the greatest ease of operation. Specify a McDonald Swing Joint for complete satisfaction.

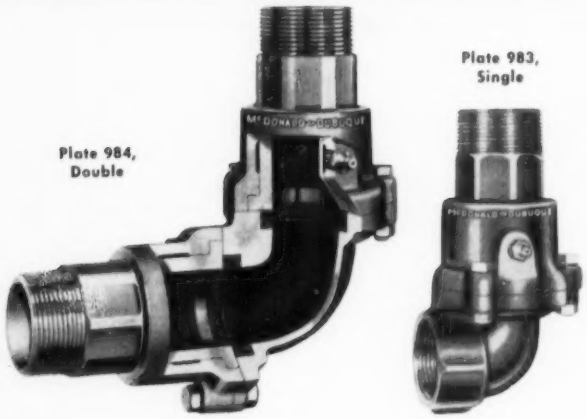

Plate 984, Double

Plate 983, Single

McDonald Master Swing Joint

The Master Swing Joint represents all the accumulated experience and research of the firm that first placed the swing joint on the market . . . it is the finest of its kind; simple, trouble-proof, unmatched for easy operation and durability.

For packing, a single ring is used, as shown in the illustration. Standard grease gun fittings permit the occasional use of a grease gun to assure proper lubrication and lifetime service. Construction of the brass ferrule allows convenient use of wrench.

Should it ever be necessary to replace a packing ring, the operator merely removes two bolts, swings body out of alignment, removes the old ring and replaces it with a new one.

All brass construction. SIZES: 1½", 2", 2½" and 3".

Plate 813, Single

Plate 889, Straight

Plate 814, Double

McDonald Standard Swing Joints

Bodies carefully machined on the inside eliminating unusual wear on packing. Packing gland is equally well machined for long life. A bronze friction ring prevents packing from resting on shoulders of bronze ferrule to eliminate metallic friction on packing. Each Swing Joint is fitted with ample amounts of specially prepared McDonald packing to resist the action of gasoline or oil.

SIZES: Plates 813 and 814 — ¾", 1", 1¼", 1½", 2", 2½", 3", 4", 6", 8", 10". 12" furnished on request. ¾" and 1" are all bronze.

Plate 889 — 1¼", 1½", 2", 2½", 3" and 4".

A. Y. McDONALD MFG. CO.

DUBUQUE, IOWA

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100th ANNIVERSARY — McDonald — YESTERDAY TODAY TOMORROW